JUNE 1959

Power Engineering

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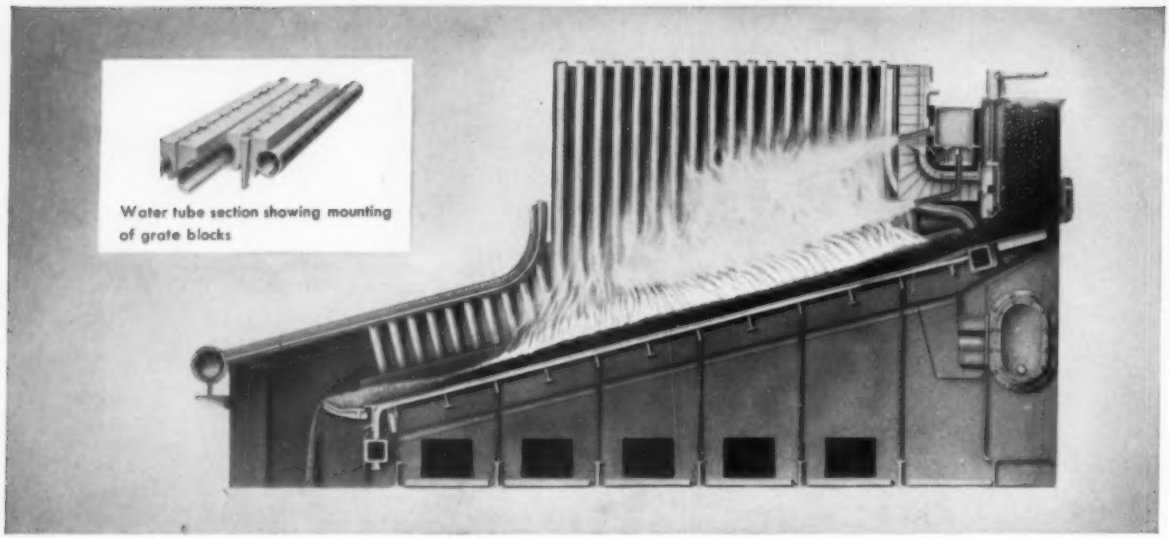
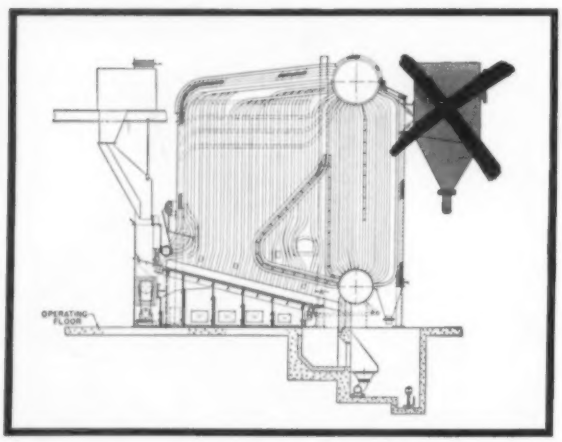
Only AE Vibra-Grate Stokers give you these 3 important benefits



Water-cooled grates. Water-cooling . . . directly connected to the boiler circulation system . . . guarantees the longest grate life available in any stoker today. Proven maintenance costs are less than one cent per ton of coal. In fact, one major installation has used less than $200.00 worth of repair parts in over four years of continuous operation!



Elimination of dust collectors and cinder return systems. Vibra-Grate burns the coal on the grate . . . dust collection and cinder return systems are not needed. You will never have to be selective in the grade of coal you burn either. Vibra-Grate feeds wet or dry fuel, high or low grade coals. It can burn gas or oil singly or in combination with coal. Overfire air assures complete combustion, giving absolute freedom from smoke at high or low ratings.

Higher efficiency. Intermittent vibrating motion of the grate feeds and moves the fuel . . . insuring even, compact distribution on the bed. A combustion-controlled electric timer determines the vibration frequency as required by fuel and steam demand. There are no light spots or holes to reduce efficiency. The grate supports form air-tight zoned sections dampered to permit accurate regulation of undergrate air.

THE AE VIBRA-GRATE offers advantages in stoker operation and efficiency that have never been available before, because it is the only stoker which combines the maintenance saving features of water-cooling and the high efficiency features of a vibrating grate and controlled zone undergrate air. Only from Vibra-Grate can you get such dramatic reductions in maintenance costs . . . as well as efficiencies that can't be equalled. Write for complete information on what Vibra-Grate stokers can do for you in terms of lower operating costs. American Engineering Company, Dept. S-101, Philadelphia 37, Pa.

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6 Ton Hot Reheat Header

Model test set-up of hot reheat line as reproduced above is approximately 1/10th actual size of the model. Circled area shows position of chrome-moly header in the line.

Size of this hot reheat header can be seen by comparison with men in the picture. It is 21" O.D., fabricated of 2¼% chrome, 1% molybdenum steel.

PRETESTED and PREFABRICATED by Pittsburgh Piping

PART OF A COMPLETE HIGH-PRESSURE, HIGH-TEMPERATURE PIPING SYSTEM

The model shown above exactly duplicates—from an engineering standpoint—a hot reheat line which is part of a high-pressure, high-temperature piping system fabricated by Pittsburgh Piping.

The inset shows the position and relative size of the header in the line, and the main illustration is an actual photograph of this header as fabricated in our shops. The complete system, which includes chrome-moly and stainless steel piping fabrication, is one of scores of installations which we have model-tested, fabricated, and erected.

Use this experience on your next piping job . . . electric generating station, nuclear power installation, chemical processing plant, refinery, mill, or factory. We are specialists with complete facilities, and we assume responsibility for every phase of the work—from blueprint through erection.

Promoting Progress ***IN POWER AND PROCESS PIPING***

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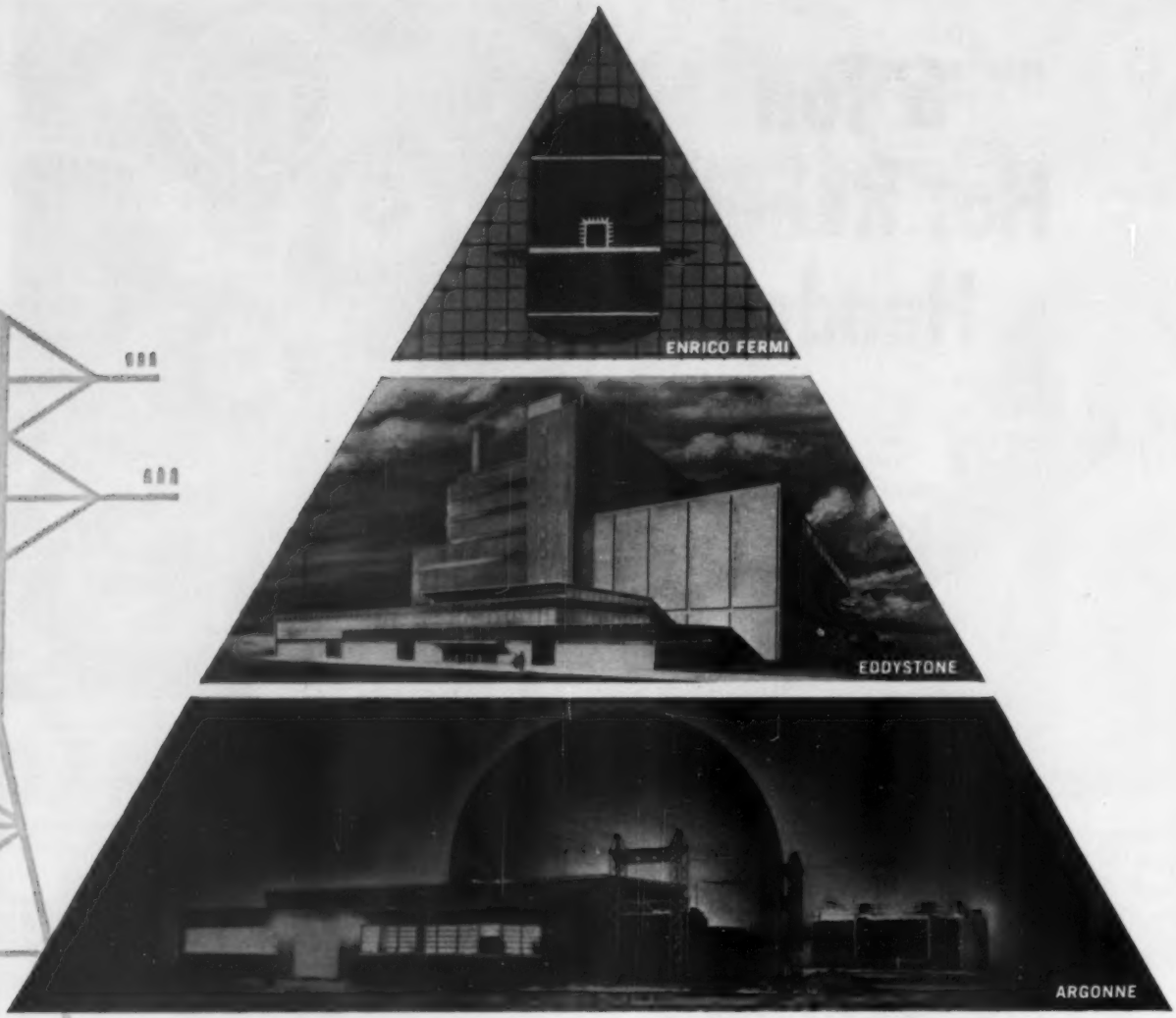

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with advanced water treatment methods and processes

Enrico Fermi Atomic Power Plant. First large-scale fast-breeder reactor in the United States. Built to produce steam for commercial electric power and to advance research. To go into operation in 1960.

Eddystone Station, Philadelphia Electric Company. Largest supercritical plant in the world—highest temperature (1200°F), highest pressure (5000 psig). To go into operation in 1959.

Argonne National Laboratory, the Experimental Boiling Water Reactor. First reactor built to explore the commercial use of atomic energy. Now in operation.

All three installations have in common not only unique water treatment requirements but also the incorporation of scavenger demineralizers. These units were pioneered by Graver Water Conditioning Co. to meet the ultra-pure water requirements of supercritical and nuclear power plants. Now Graver is offering them for use in sub-critical plants where they represent a major breakthrough in problems of internal contamination which are of concern to all power plants.

Our work in boiler feedwater treatment for sub-critical, supercritical and nuclear power plants shows the breadth of Graver's contribution to power progress. Our pioneering of scavenger demineralizers for wide application is but one example of the research and development which goes on constantly at Graver to keep apace of this fast growing industry and to introduce new equipment and methods for the further advancement of the field.

GRAVER

Industrial Water Treatment Dept. I-322
GRAVER WATER CONDITIONING CO.
Division of Union Tank Car Company
216 West 14th Street, New York 11, N. Y.

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NBP BPA

PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL PLANTS

ENGINEERS' PREVIEW

FUROR over the recent TVA order of a large turbine generator from British manufacturer C. A. Parsons recalls the fact that the first Parsons turbine generator in this country was sold to Commonwealth Edison in 1912, and went into operation in Fisk Station in 1913. It is a 25-cycle, 25-mw unit, and is still in operation, used as a back-up should one of the 20-mw frequency changers be out of service. Its boilers now gone, steam is furnished by a 30-mw topping turbine.

Ten years later, Parsons sold Commonwealth Edison a second unit, this one rated at 50 mw, then one of the largest and most efficient in the world. This was taken out of service only two years ago, to make room for the new No. 7 unit at Crawford Station. This unit, incidentally, was delivered by water direct from England to the site.

GEORGIA POWER CO makes water power news this month with announcement of the opening of its Oliver Dam hydroelectric station. Dam is located on the Chattahoochee River near the city limits of Columbus, Ga, and has an installed generating capacity of 60,000 kw, with an annual generation of 255,000,000 kwh. The plant is designed for completely automatic, remotely controlled operation.

WHAT'S IN THE WORKS for tomorrow's power plant? In Westinghouse's book, these are key developments:

A longer turbine rotor blade that will permit construction of a supercritical pressure, cross-compound turbine of 800-000-kw capacity; switchgear which uses a gas — sulfur hexafluoride — as the medium to interrupt and extinguish electric arcs; extra high voltage transmission which will enable the nation's 350 electric utilities to tie into one national power grid.

Finally, advancements in atomic power have made it possible for Westinghouse to announce that it is prepared to design, develop and build a 330,000-kw nuclear power plant. Such a plant could be operating within five years and could produce power at costs competitive with fossil fuels in high fuel cost areas, the company states.

RUSSIAN scientific journals, especially in physics and chemistry, are being made available in translation by Consultants Bureau, Inc, of 227 W 17th St, New York 11, N. Y. Among the journals offered are: *Cement*, *Metallurgist*, *Soviet Journal of Atomic Energy*, *Colloid Journal*, *Journal of Applied Chemistry*, *Journal of General Chemistry*, and the chemistry, physical chemistry and geological sciences sections of the Proceedings of the Academy of Sciences, USSR. *Soviet Science and Technology*, in annual 12-issue subscription at $25, is a handy monthly guide to translated Russian research, providing English translations of the tables of contents of current Soviet journals.

MEETINGS: Semi-annual meeting of ASME, scheduled for June 14–18 in St. Louis, Mo, will present information on topics such as safety in chemical processing, potable sea water, diesel engine noise, direct conversion of heat into electrical energy and heat transfer in nuclear reactors. Over 30 sessions are scheduled for the five-day meeting at the Chase-Park Plaza Hotel.

American Nuclear Society will meet in Gatlinburg, Tenn., June 15–17. Heading the list of speakers are Dr. Eugene P. Wigner, nuclear physicist of Princeton University; John A. McCone of the AEC; and Dr. Jules Gueron, top official of the European Atomic Energy Community.

Annual meeting of the American Society for Testing Materials will be held in Atlantic City, June 21–26.

Summer and Pacific General Meeting of AIEE will be held June

Russia—the Country and the People Behind the Current Crisis was discussed by R. H. (Dick) Morris, Editorial Director, POWER ENGINEERING, at a recent meeting of San Jacinto chapter of Texas Society of Professional Engineers. Morris (left) talks here with Jim Montgomery of Tidewater Oil and chairman of group

21–26 at the Olympia Hotel in Seattle, in conjunction with the AIEE Air Transportation Conference. The meeting also will be a highlight of the 75th birthday of the Institute, which was founded in 1884, with a membership of 71. Today it has more than 52,000 members throughout the world.

Fourteenth Annual Conference and Exhibit of the Instrument Society of America will be held in Chicago. Conference will run for six days, starting September 20. Exhibit will be open Sept 21–25.

SELF-IMPROVEMENT through home study and company-sponsored in-plant programs continues to be a potent force in bettering the quality of work in the power industry. Two items relating to this theme:

Just off the press is a new in-plant training brochure compiled by the ASM Metals Engineering Institute — the home study school of the metals industry. The brochure offers full details on Institute procedures for setting up and servicing in-plant study groups using MEI courses. It may be obtained on request by writing to Metals Engineering Institute, Dept RV-1, 7301 Euclid Ave, Cleveland 3.

The 1959 Directory of 58 private home study schools which have been examined and meet standards of the National Home Study Council has recently been released. Founded in 1926 to promote sound educational standards and ethical business practices, the National Home Study Council admits schools only after careful examination. The 1959 Directory may be obtained by writing the Council at 1420 New York Ave, N W, Washington 5, D. C.

HONORS: President-elect of the Edison Electric Institute is Allen S. King, president of the Northern States Power Co.

John M. Crawford, sales manager for large steam turbine-generator units, Allis-Chalmers, has been awarded an Alfred P. Sloan Fellowship in Executive Development at the Massachusetts Institute of Technology. Crawford is one of 45 young executives selected on a national basis by MIT for a 12-month study of industrial management.

Two Detroit Edison men have won their company's Alex Dow Award for outstanding achievement. The winners are George L. Schlaepfer, coördinator of international coöperation programs, and Frank M. Mason, manager of Edison's Romeo, Mich, office.

Kenneth B. Ris, president of the Griscom-Russell Co has been appointed to serve as the firm's chief executive officer.

Allen Ray Putnam has been named managing director of the American Society for Metals. Putnam comes to the Society from Detroit where he is assistant executive secretary of the American Society of Tool Engineers.

Gordon S. Brown has been appointed as Dean of the School of Engineering of MIT. For the past seven years Dr. Brown has headed the Department of Electrical Engineering.

William F. Ryan, former vice president of Stone & Webster Engineering Corp, will be awarded the 1959 NSPE Award for outstanding service to the engineering profession. The award will be made on June 20 at NSPE's Silver Anniversary meeting in New York City.

WHY PREMATURE FAILURE of redwood cooling towers? Early study by the California Redwood Assn indicated that the excessive use of chlorine, combined with alkaline circulating water, was responsible for very rapid delignification, which was causing premature failure in some towers.

Later CRA suggested that adding even small amounts of chlorine to the circulating water had a deleterious effect on wood's ability to resist biological attack. At first, this idea was widely discounted, but as increasing confirmation was obtained in the form of field data, it gained wider acceptance.

Now, some seven years after it was first made, the Association's suggestion has been confirmed by work done at two of the world's leading wood laboratories.

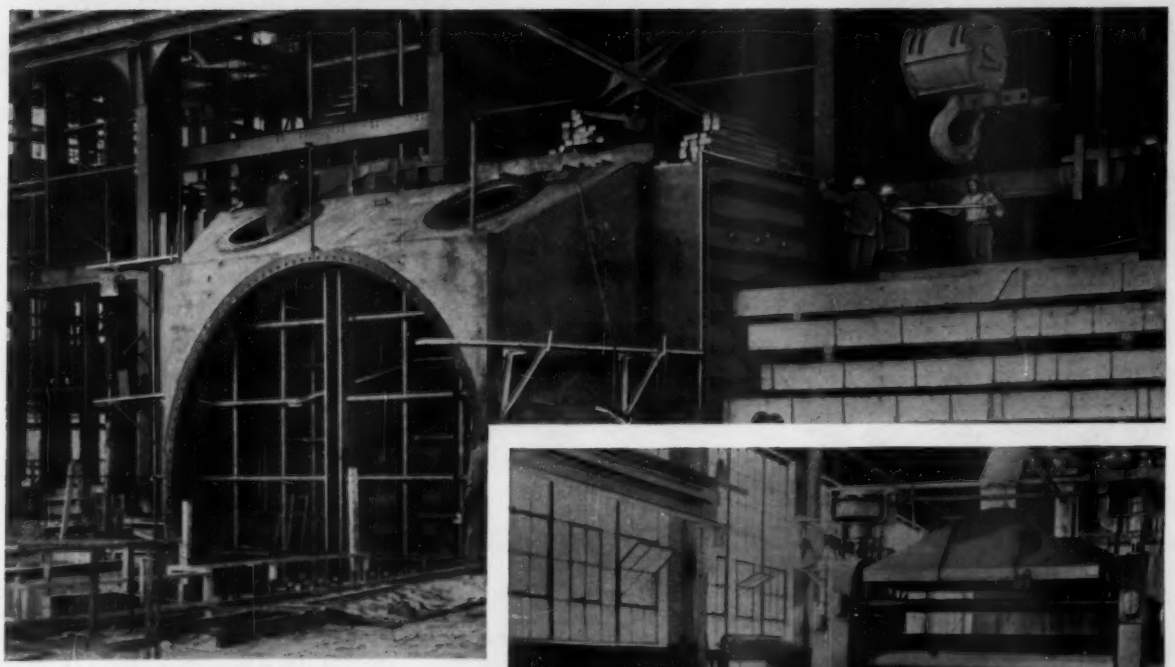
Dr. C. G. Duncan of the U. S. Forest Products Laboratory reports that in studies of about 100 fungi of the soft rot group, the evidence indicates that chlorine appreciably accelerates the attack on softwoods by organisms of the soft rot type.

Independent confirmation came from Europe. An article in *Timber Technology* said that the (British) Forest Products Research Laboratory had been unable to grow soft rot fungi on coniferous woods unless the wood samples first were treated with chlorine water.

A recent report prepared by California Redwood Assn concludes: "The surface deterioration of redwood in cooling tower service may virtually be eliminated by avoiding the use of chlorine and using a non-oxidizing algaecide in the treatment of the circulating water."

MERGING of Foster Wheeler Corp into North American Aviation, Inc, is being worked out in a plan which calls for the issuance of one share of North American stock for each share of Foster Wheeler. The plan contemplates the issuance by North American of approximately 595,473 shares, representing an addition of about 7.3 per cent to the 8,119,890 shares outstanding. Both companies will submit the plan to their respective stockholders for approval at special meetings to be called for that purpose, possibly on the same date early in July.

7-TON COPPER-ALLOY PLATES FOR LARGE SURFACE CONDENSERS



TOP: View of the new Clinch River Plant of Appalachian Power Co., at Carbo, Va. **ABOVE:** Tubing one of the two huge Allis-Chalmers surface condensers. The 26' x 15' openings in the shell use two Anaconda Leaded Muntz Metal-274 plates, each 156" x 189" x 1½" and weighing 13,700 lb. American Brass furnished the eight plates required, as well as the Arsenical Admiralty-439 tubes for the unit above — 19,100 lengths, ⅞" x .049" x 30'. **RIGHT:** The big rolling mill at American Brass Company's Detroit Division which produced the plates.

THE unusually large plates required for the tube sheets at Clinch River Plant are standard items of The American Brass Company, which produces plates of copper and a number of copper alloys in rectangular sizes up to 156 inches in width and 15,000 pounds in weight. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half circles can be produced up to 13,000 pounds in weight.

ROLLED PLATES SUPERIOR. Anaconda rolled plates are commercially flat, accurate in dimensions, and free from surface imperfections and porosity often prevalent in cast plates.

SPECIAL JOBS. Whenever you have a problem involving extremely large plates in standard or special copper alloys, The American Brass Company will gladly assist in its solution. For general information on Anaconda Condenser Tubes and Plates write for Anaconda Publication B-2: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA®

Tubes and Plates for Condensers and Heat Exchangers

MADE BY THE AMERICAN BRASS COMPANY

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WHAT THEY TELL US

▶ **RARE** indeed is up-to-date, meaningful material on operating costs in the power field. That's why John S. Cole's series on Industrial Power Plant Accounting, which began in the April issue, page 68, is so valuable. Readers have been quick to appreciate this. Writes James C. McElnay, chief engineer of the Greater Niagara General Hospital in Niagara Falls, Ontario:

> The article . . . by John S. Cole was very good indeed, and I would like to see much more of this type of article; it covers the necessary heart of power plant engineering, ie, the cost of steam, etc. I hope to see more of this kind of material.

▶ **75 YEARS** in the manufacture of water columns, water level gages and other equipment for checking water levels in boilers and other vessels, is a record being celebrated this year by Reliance Gauge Column Co. This year also marks the 40th anniversary of president J. Rowland Brown, who joined Reliance as general manager in 1919.

> Recent years have seen the development by Reliance of alarm and light signal equipment adapting the use of isolated electrode circuits. Installed as an adjunct to the water column, or in exterior supplementary devices, this facility for prompt response has been supplied for alarms, for fuel cutout, or for pump control.

They tell us that Reliance was the originator of the safety water column.

▶ **ANYTHING** new under the sun? A letter from reader E. W. K. describes a solar-energy plant which operated in 1911 in Philadelphia. Perusal of our old volumes reveals an article describing the plant in a 1912 issue of *The Practical Engineer*, now POWER ENGINEERING. It was written by Frank Shuman, designer and builder of the plant.

> Sun-power plant had an output of around 100 hp, and was used to pump irrigation water, 3000 gpm at a head of 33 feet. Total costs were comparable to a coal plant of similar size when the price of coal was $2.66 per ton. Actual capacity would have been much greater, and costs much lower, had the plant been in an area closer to the equator.

▶ **THERE** *was* a molasses expert among the readers of this department for February! He is H. B. Wayne of Woodhaven, N. Y. In response to our question about heat transfer rates for molasses, using hot water in pipe coils, Wayne tells us:

> Thermal properties of molasses vary appreciably, being influenced by sucrose concentration, moisture content and handling temperature. Consult the table giving specific heat of pure sucrose and sucrose solutions in Lyle's Technology for Sugar Refinery Workers (3rd edition).
>
> Thermal conductivity values for molasses may be derived from the following formula:
>
> $k = (306 + 0.643t - 0.001t^2) \times (1 - 0.0054w)\ 10^{-3}$
>
> where;
>
> k = Thermal conductance, Btu/hr/ft²/F/ft
>
> t = Temperature F
>
> w = Sugar weight in solution, per cent
>
> Equivalent metric units may be expressed as:
>
> $k = (486 + 1.55t - 0.005t^2) \times (1 - 0.0054w)\ 10^{-3}$
>
> where;
>
> k = Thermal conductance, Kg-cal/hr/meter²/C/meter
>
> t = Temperature, C
>
> w = Sugar weight in solution, per cent
>
> More detailed information is available from Bulletin No. 34, A Literature Survey of the Thermal Conductivity of Liquids, published by Louisiana State University.
>
> It should be noted, *k* are conductance values for molasses only. Overall thermal conductivity will be less, since the latter includes film and scale resistances for the heating fluid, molasses and coil wall material.
>
> Use of hot water for molasses heating is preferred to steam. The former, using forced convection available from pumping, offers more uniform heat transfer rates, reducing possibility of temperature gradients throughout the coil. Since molasses is a carbohydrate, need for maintaining close temperature control is necessary to prevent carbonization. Also, excessive temperatures may cause CO_2 formation, which will reduce thermal conductance and lower pumping efficiency resulting from increased viscosity.
>
> Because of the many operating variables and wide range of thermal properties, it is recommended that a safety factor of two be applied when designing heat transfer areas and pumping quantities.

▶ **R. D. LANDON's** comments in the February 1959 issue on the article by K. R. Sturley, appraising American engineering education, were read with particular interest by J. A. Forster, P. Eng., of Victoria, British Columbia, who is a past participant in Dr. Sturley's training program. Forster comments:

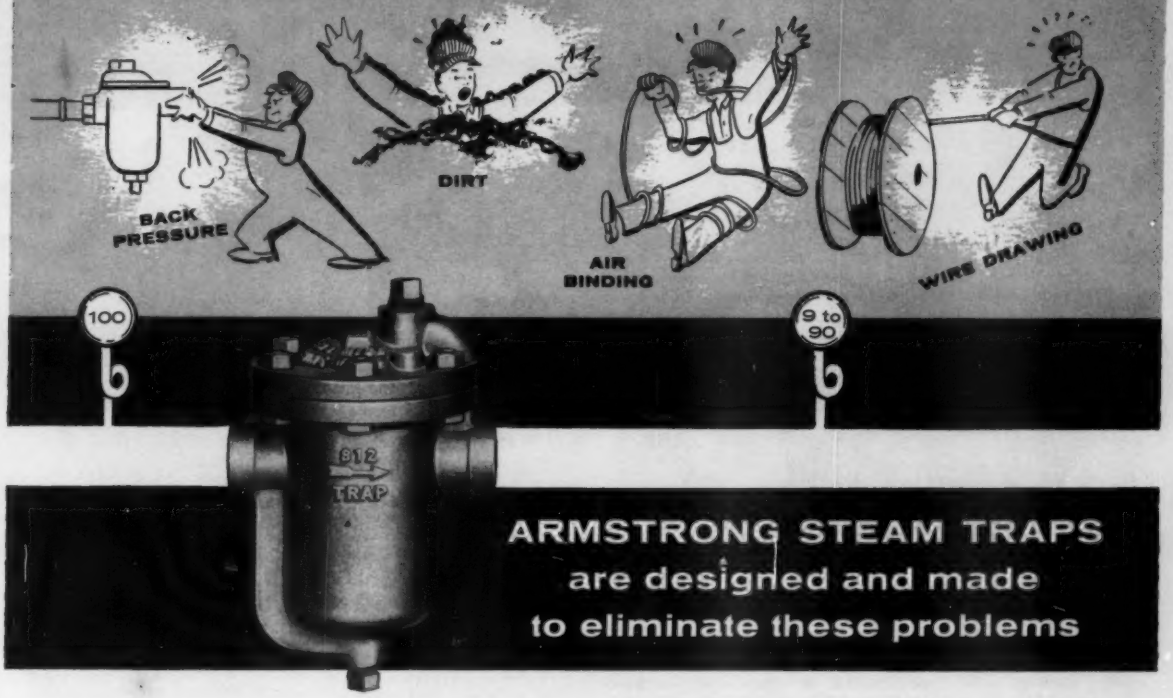
> The existence in North America of coöperative training methods whereby students spend part of their time at university and part in industry, is recognized by Dr. Sturley, I am sure. The attitude he quotes of one executive, that "we pay for the brains of the engineer, not his hands," should not, I agree, be taken as a true indication of the majority opinion; as you say, satisfactory work experience should be a requirement for graduation. This is emphasized in England.
>
> In my own experience, coöperative training was in use in England in 1929. In one scheme, the student spent four months per year in industry and the remainder at college. This is known as a "sandwich course" and is now in very wide use. In England there are few summer jobs available to the student which will pay him well enough to cover his year-round expenses. However, the student-apprentice schemes cater to the student who must pay his way and, in addition, they are being used to select the brighter apprentices in the technician class who can reach higher stages.
>
> In contrast, in North America the number of students who, out of economic necessity, work at employment not related to their studies during summer and even during the semester, is large compared with the number on coöperative courses. The employment with the highest rate of pay is chosen, to give maximum assistance in paying for the university course, in many cases.
>
> It is my opinion that present-day needs are such that industry should very seriously consider a wide-scale adoption of coöperative schemes. They will entail expenditure during the students' education, but they will ensure that the required product is available on completion of the course, and eliminate the annual scramble for graduates of relatively unknown potentialities.

▶ **QUOTABLE** quote comes along from Gardner Barker, president of Thomas J. Lipton, Inc, via National Business Publications:

> If you don't make your product obsolete, you can be very sure that somebody else will.

Having introduced the tea bag, to replace loose tea, Lipton's is now busy making the tea bag obsolete, with instant tea.

Have you ever been troubled by any of these steam trap problems?



ARMSTRONG STEAM TRAPS are designed and made to eliminate these problems

BACK PRESSURE . . . Armstrong Traps operate on any back pressure—or vacuum, for that matter. As long as there is a pressure differential across the trap, it will close on steam and open for condensate. Even the high back pressure caused by blow through of one or more traps in the system will not disturb Armstrong Traps. Other than a reduction in capacity, Armstrong Traps are unaffected by back pressure.

DIRT . . . Armstrong Traps are not affected by ordinary dirt. When the trap opens condensate swirls down under the edge of the bucket and up through the discharge orifice. Dirt is kept in suspension and discharged along with the condensate. For very bad dirt conditions, Armstrong offers traps with integral strainers. These cost less than a trap plus a separate strainer.

AIR BINDING . . . Armstrong Traps cannot air bind. Air in the system passes through a vent in the top of the bucket. It collects in the top of the trap and is discharged with the condensate. There is no chance for it to stop the trap. For low pressure on-and-off units where large amounts of air accumulate while the steam is off, Armstrong offers open float and thermostatic air vent traps in a complete range of sizes.

WIRE DRAWING . . . Armstrong Traps are designed and made to resist wire drawing. The valve and seat are tough stainless steel. The valve opens and closes tightly with a fast action and is always water sealed. There is virtually no chance for grit or sediment to lodge in the valve, virtually no chance to create conditions that lead to wire drawing.

There's no need to accept any of these problems as "inevitable." Your local Armstrong Representative can show you how to end them all. Call him today or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.

The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

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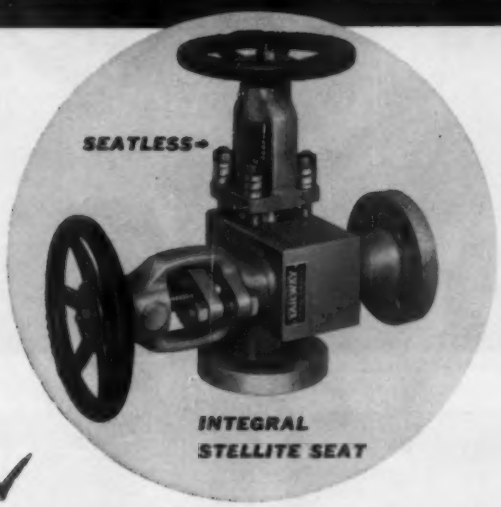
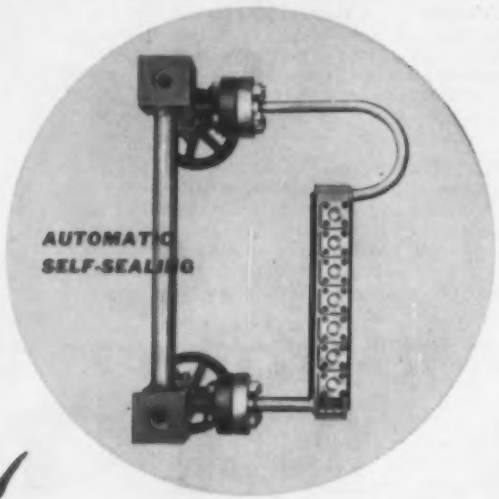
BLOW-OFF VALVES, LOW PRESSURE

This is the famous blow-off valve with no seat to score, wear, clog or leak. It's a standard in over 16,000 boiler plants. If your blow-off valves are obsolete or worn, consider new Yarways. Another point—all Yarway design and metallurgical improvements are interchangeable with parts of earlier model Yarway valves. See Bulletin B-427.



BLOW-OFF VALVES, MEDIUM & HIGH PRESSURE

A new development—the Yarway Medium Pressure Unit Tandem Valve for pressures up to 665 lbs.! A Yarway Seatless Valve and a Yarway Integral Stellite Seat Valve are combined in a forged steel body for rugged dependability. There's no other blow-off valve like it! Ask for Supplement A, Bulletin B-435. For high pressure Yarway Unit Tandem Valves to 3206 lbs., ask for Bulletin B-435.



WATER LEVEL GAGES

Yarway Color-Port Gages give you a new standard of service convenience and readability for water gages. They are automatically self-sealing, have individual port assemblies that can be replaced in minutes with the gage in the line, and show brilliant red and green readings. All these contribute to greater efficiency. Two lines—medium pressures to 1050 psi; high pressures to 3000 psi. See Bulletin WG-1815.

REMOTE WATER LEVEL INDICATORS

Yarway Remote Water Level Indicators have new "wide-vision" faces, can be pressure and temperature-compensated, may be used under Code Case #1155, can be equipped with remote lights or horn signal alarms or electronic secondary indicators. Add these features to your plant for greater safety and convenience. See Bulletin WG-1825.

CHECK-UP TIME AGAIN!

can help improve your steam plant efficiency

HIGH PRESSURE/HIGH TEMPERATURE VALVES

Scores of high pressure/high temperature valve applications call for the Yarway Welbond Valve. Only Welbond combines such features as non-pitting stainless-steel valve stem, non-distorting integral stellite seat and self-aligning disc, special inhibited packing, accessible working parts. Two lines—1500 psi and 2500 psi. See Bulletin B-453.

STEAM TRAPS

Modern Yarway Impulse Steam Traps will improve efficiency of your power plant and reduce maintenance. The Yarway Impulse Trap features only one moving part, is good for all pressures, has stainless steel construction, small size and light weight, is quick heating, and non-freezing. There is now a Yarway Impulse Trap for every steam plant application—indoors and out. See Bulletin T-1742.

EXPANSION JOINTS

"Boiler check-up time" is "steam line check-up time," too! Yarway Gun-Pakt Expansion Joints offer unequalled features in slip-type joints. Repacked under full steam pressure with no shut-downs or service interruptions. New one-piece design for body and gland. New convenient arrangement of packing guns. Durable chromium-plated seamless steel sleeves. Positive alignment. See Bulletn EJ-1917.

THESE FREE ARTICLES WILL HELP YOU IN YOUR JOB. Write for them.

"HOW TO KEEP YOUR BLOW-OFF VALVES ON THE LINE"
Reprint of recent article by Yarway Engineer, E. E. Finsel

"OVERHAUL H-P BOILER WATER GAGES RIGHT"
Reprint of magazine article by Yarway Engineer, Frank Ptacek

"DESIGN PROCEDURE FOR SLIP-TYPE EXPANSION JOINTS"
Reprint of new article by Yarway Engineer, Kenneth S. Roberts

"HOW SHOULD WE OVERHAUL OUR STEAM TRAPS?"
Helpful, timely article by Yarway Engineer, L. G. Chase

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
STEAM PLANT EQUIPMENT

For more data circle 506 on Post Card

AT ASHLAND, KY. WORKS OF ARMCO STEEL CORPORATION

"Increased boiler capacity can often be obtained by modernizing boiler cleaning equipment. Another benefit of such modernization is more efficient utilization of the fuel . . . getting more heat into the steam for useful work and wasting less heat up the stack.

For example, at the Ashland, Kentucky Works of the ARMCO Steel Corporation there are four boilers that were unable to supply the growing steam requirements of the plant. The high exit gas temperatures suggested that a study be made to determine whether the cleaning could be improved to provide additional capacity. This study indicated that more steam from the same fuel could be expected if high pressure long retractable blowers were used for cleaning instead of the rotary blowers with which the boilers were originally equipped.

The expected results seemed sufficiently promising and it was decided to modernize the cleaning equipment of one boiler. The seven rotary blowers were replaced with four Diamond Long Retracting Blowers, one of which is shown below. This modernization proved to be justified as the boiler's maximum steam output was increased 11% and the exit gas temperature was reduced approximately 100° F.

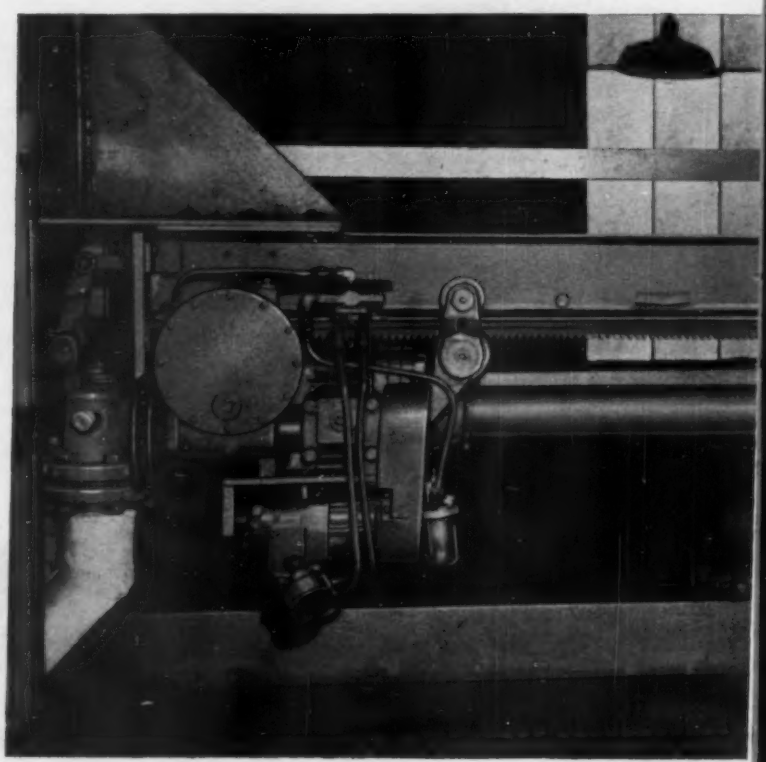
A "Boiler Cleaning Modernization Program" is well worth careful consideration because it can mean substantial savings in so many ways. In addition to increased capacity and more efficient fuel utilization, there is reduced maintenance . . . also reduced operating costs when motorized units and automatic operation are installed. Even though your boiler cleaning was the best at the time it was installed, improvements since then will probably pay off. For many years Diamond has been doing continuous research to improve boiler cleaning and boiler cleaning equipment.

Ask the nearest Diamond office (or write directly to Lancaster) to make a study of your boiler cleaning . . . the possible savings may surprise you."

DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO

DIAMOND SPECIALTY LIMITED • WINDSOR, ONTARIO



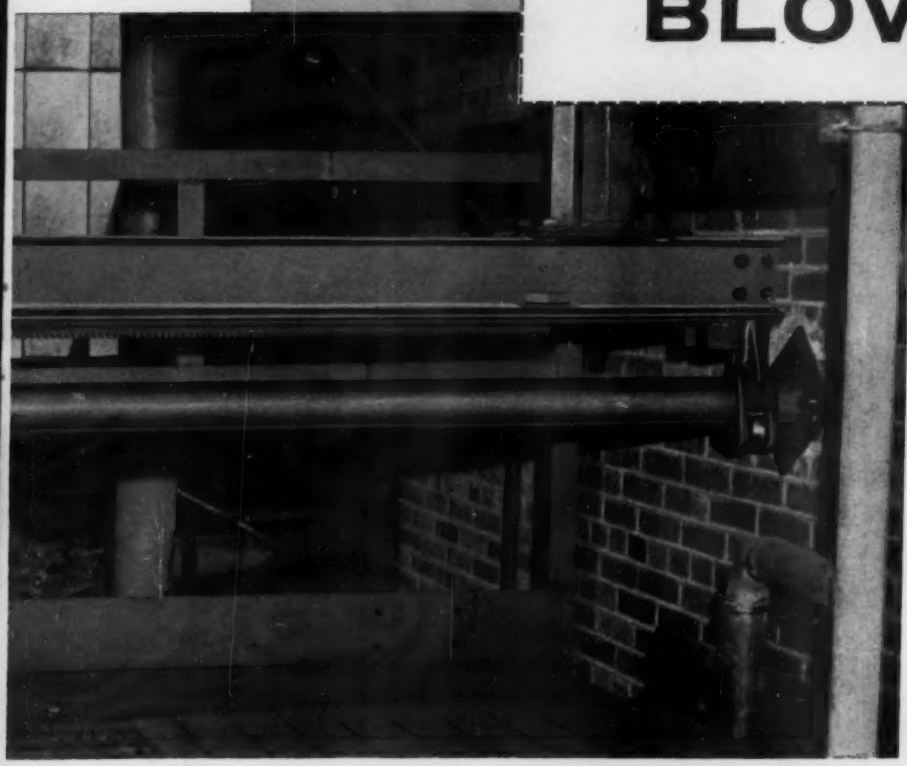
The Mark of

BETTER BOILER CLEANING AT LOWER COST

11% More Steam 100° F Lower Exit Gas Temperature

RESULT FROM BOILER CLEANING MODERNIZATION PROGRAM

Using DIAMOND LONG RETRACTING BLOWERS

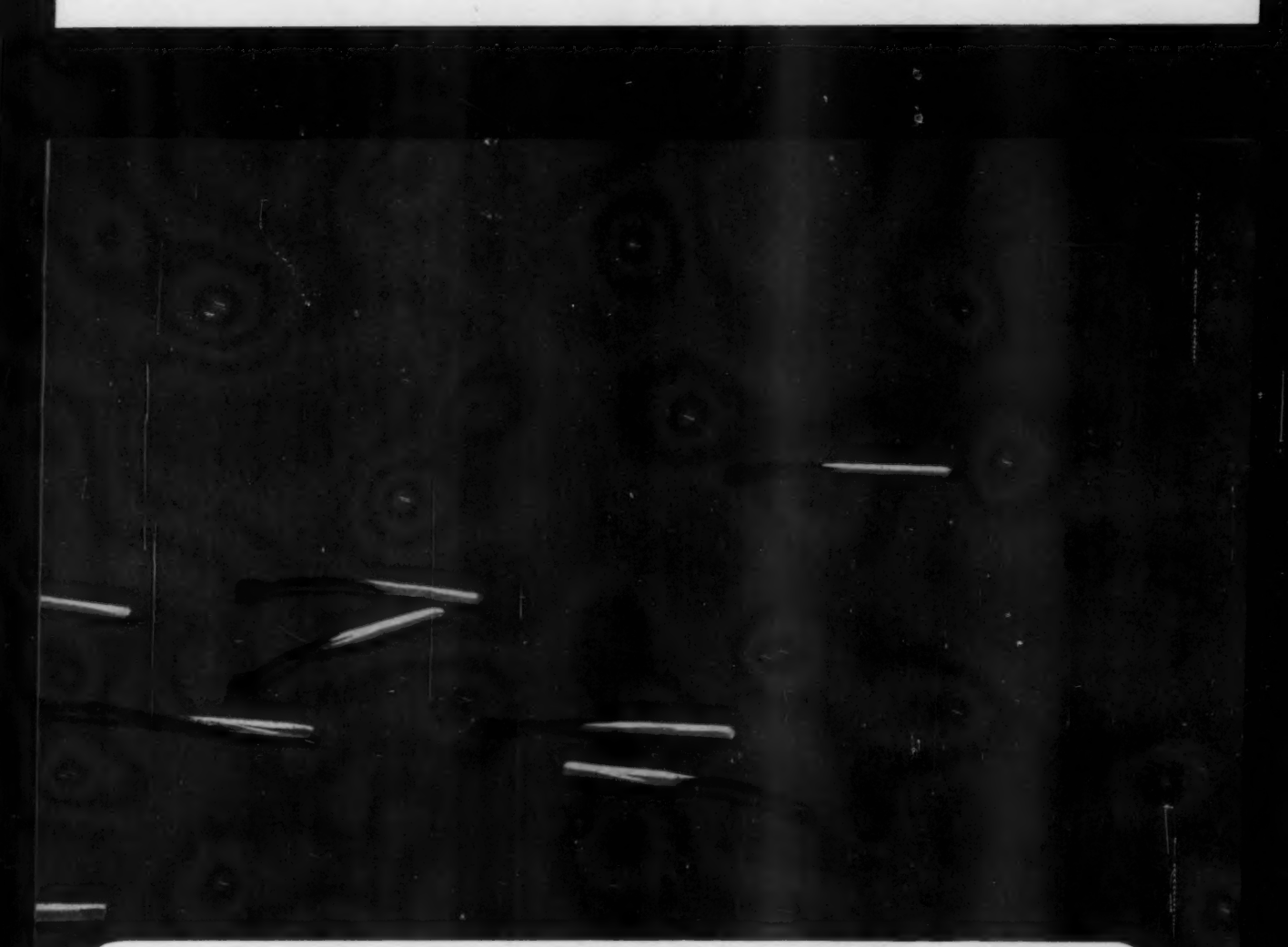


One of the four Diamond Long Retracting Blowers used to modernize the cleaning of the first boiler at the Ashland Works of ARMCO Steel Corporation. The results were so satisfactory that the three other boilers in this plant are now also being modernized.

8257

For more data circle 507 on Post Card

The Continuing Search For Economical Energy



Now—Btu's from coal that "Can't Be Burned"

Utilities who thought it couldn't be done, are now burning low-cost, low-grade, high-ash coal—helping to keep kilowatts America's biggest bargain.

The reason? B&W fuel research that led to the design of the Cyclone Furnace. Fact is, the B&W Cyclone Furnace was *designed* to burn the really "tough" coals—and squeeze the maximum Btu's from every pound.

Behind the Cyclone's success are more than 33,000 B&W fuel analyses. With this tremendous background and experience, B&W can build fuel burning equipment around the fuel *you'll* burn. It means you can utilize available low-cost fuels you could never use before.

Important to you, too, is B&W's complete objectivity in making recommendations. For B&W manufactures all types of fuel burning equipment—for every application. Why not discuss your special requirements with us now. Write to The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

G909-CS

EDWARD "848" SERIES GLOBE VALVE
(ANGLE TYPE ALSO AVAILABLE)

What's New from Edward Valves

New Products . . . Problems and Solutions. . . Information on Steel Valves from Edward, Long-Time Leader in the Field!

Major Improvements at No Extra Cost Mark New "848" Series Forged Steel Stop Valves

In an industry where any change in design is "news," Edward is proud to introduce a new line of 600-lb forged steel stop valves with so many major design improvements *at no increase in cost.* These Rockwell-built Edward valves are suitable for air, water, oil and other hydrocarbons, anhydrous ammonia and other gases, steam and other non-corrosive fluids.

NEW MATERIALS USED THROUGHOUT

Besides tough drop-forged steel, which is the basis of these valves, Edward introduces such innovations as stainless steel gland bolts, an aluminum-bronze yoke bushing, solid disk of chromium-cobalt-tungsten stainless steel, spiral wound gasket of stainless steel and asbestos, and special alloy cap screws linking body and bonnet.

NEW IMPROVED BODY-BONNET JOINT

Four molybdenum alloy cap screws secure bonnet to valve body. These compact, high-strength cap screws require less space than ordinary nuts and bolts, can be handled with one hand, and deliver maximum compressive force with minimum tightening torque. A new spiral wound gasket, consisting of some 20 turns of stainless steel and asbestos, provides controlled compression not possible with ordinary flat gaskets. Because this spiral wound gasket is free to expand and contract as needed, it "takes up the slack," maintains a leak-proof seal between body and bonnet.

NEW SOLID DISK OF SPECIAL ALLOY

Disk is made of chromium-cobalt-tungsten stainless steel. This new alloy has added resistance to erosion, holds its hardness better under high temperatures than other disk materials. Disk is lock-welded to disk-nut, eliminating wobble and chatter—especially important when valve is called upon for throttling duty.

INTEGRAL STELLITE SEAT FOR LONG LIFE

Valve seat is Stellite—a harder, longer-wearing material with excellent resistance to corrosion, erosion and temperature. Seat is integrally welded to body.

"848" SERIES ROCKWELL-BUILT EDWARD VALVES are available in ¼", ⅜", ½", ¾" and 1" sizes. They are rated at 600 psi—at 910F in carbon steel and at 1030F in chrome-molybdenum steel. Globe or angle types, with screwed or welding ends. Write for facts on performance . . . price . . . and delivery. Address *Edward Valves, Inc., 1202 West 145th Street, East Chicago, Indiana.* (Subsidiary of Rockwell Manufacturing Company.) Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St. W., Montreal 1, Quebec.

EDWARD STEEL VALVES

another fine product by

ROCKWELL

Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressure up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.

For more data circle 509 on Post Card

HELPFUL WATER CONDITIONING DATA FROM BETZ

WHAT TO DO ABOUT SLIME

Biological fouling is a serious problem in cooling water systems. This helpful discussion reviews the problem and tells what to do about it.

BIOLOGICAL fouling in cooling water systems is the result of excessive growth and development of slime and algae. The principal difference between the two is that algae are capable of manufacturing their own food; fungi cannot.

Algae commonly are found in all surface water supplies. They range in size from unicellular microscopic plants to plants of more than one hundred feet in length. Although these plants are found usually in fresh and salt water, a few species are terrestrial. The species which are of primary importance in cooling water systems are the microscopic fresh water types, however, under unusual conditions the larger marine types also may become an industrial menace.

Because sunlight is necessary for the growth and development of these plants, recirculating cooling water systems are plagued with the problem of algal growths to a greater extent than once-through systems where the cooling water is not usually exposed to direct light. Abundant algal growths in spray ponds and in cooling towers will interfere with proper water distribution and thus prevent the desired cooling effect. Large masses of algae will plug screens and restrict flow in pipelines and pumps. Living algae in the presence of sunlight carry on processes of photosynthesis which result in the manufacture of food and the liberation of oxygen. Masses of living algae on metal surfaces can accelerate corrosion in the form of pitting because of the depolarizing action of the oxygen released. Accumulations of dead algae lodged in heat exchange units also can set up local cell action which can cause severe pitting of the metal.

Slime is an accumulation of microorganisms and whatever inorganic and/or organic debris may become embedded in the mass. The microorganisms usually found in these deposits are members of the filamentous fungi, yeasts, and bacteria. Slime also may contain dead algae which have been entrapped in the mass. In general, dark areas or those of low light intensity are more favorable for this type of biological fouling. The microorganisms do not utilize light to manufacture their food, being totally dependent upon the food available in the cooling water system.

The most common varieties of bacteria and fungi found in cooling systems are the air-borne types. The slime forming bacteria have a gelatinous capsule which not only serves to entrap other materials which add to its bulk, but also serves to protect the bacteria against the action of chemical and physical agents.

Chlorine

Chlorine is probably the agent most widely used for control of microbiological deposits in recirculating systems. In the absence of substances which cause a high chlorine demand, chlorine is usually the most economical method of treatment. It is highly toxic and acts quickly to kill bacteria. A chlorine residual of 0.5-1.0 ppm will usually destroy most microorganisms.

However, the amount of chlorine required for the control of biological fouling in any individual system is governed by numerous factors. Chlorine requirements are affected by the quality of the makeup water to the system, water temperatures in the system, air to water ratio of the system, the amount of contamination by reducing agents and the type and amount of bacterial and fungal contamination.

For control of the slime and algae problem in any system, it is necessary that sufficient chlorine be fed to secure the required residual chlorine content of the treated water. Further, this necessary chlorine residual must be maintained in the system for the time interval required for microorganism control.

Chlorinated Phenols

Many phenolic materials and particularly the chlorinated phenols have found use in industrial microbiological control. The toxicity of these materials varies widely between different species of bacteria and fungi.

The chlorinated phenols which have been most widely used in recirculating cooling water systems are the sodium salts of trichlorophenol and pentachlorophenol. Sodium pentachlorophenate is probably in most widespread use either alone or combined in commercial formulations with sodium trichlorophenate. Sodium pentachlorophenate is a soluble and stable material. It does not react with most inorganic or organic chemicals which may contaminate a cooling water system. A broader spectrum of biological activity can be achieved by the use of more than one chlorinated phenolic compound. For example, the simultaneous use of a trichlorophenate with a pentachlorophenate. Additional benefits may be gained by the combined use of metallic ions such as copper and zinc. Where a concentration of 200 ppm of a single phenolic compound may be required for satisfactory control of organic growths, combinations of this type have been successful in the range of 60-100 ppm.

With the chlorinated phenols, like chlorination, there are many different feeding programs that can be employed, ranging on the one hand from the continuous maintenance of a high concentration in the circulating water to the

Betz laboratory screening program determines whether a formulation has the desired biological activity.

other extreme of intermittent addition of the material in low concentration at infrequent intervals. As with chlorination, the slime control program must be fitted to the individual system conditions.

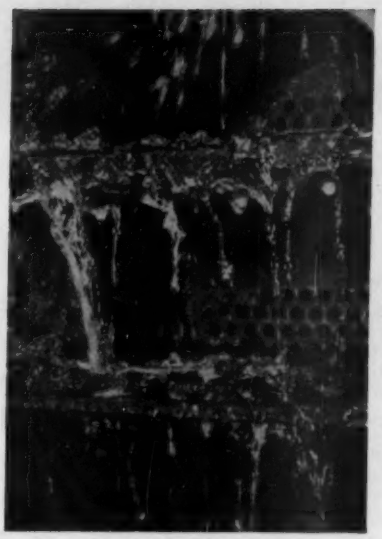
Selecting Slime Control Agents

A major factor in the decision whether to use chlorine or another slime control agent is usually made by balancing continuous chemical operating cost against equipment installation and maintenance costs.

Where liquid chlorine can be used, chemical cost will usually be lower than with other toxicants if chlorine is purchased in the larger one ton containers or tank cars, at their lower price. However, the installation cost of chlorinators and facilities for handling bulk chlorine shipments is quite appreciable. Maintenance of this equipment is an added cost.

On the other hand, other slime control agents are usually furnished in readily handled containers in liquid, powder or briquette form. Usually feeding facilities are not required when the toxicant is shot fed at infrequent intervals. Therefore continuous attention to feeding equipment is not necessary and there is no installation cost to be capitalized.

Where the system is sufficiently large and the problem sufficiently acute, the installation and maintenance expense of chlorination facilities will be justified. Where the cooling water system is relatively small or where there is only infrequent necessity for slime control agents, it will be more economical and convenient to employ agents other than chlorine. Even where the control of biological growths is handled normally by the use of chlorine, there will frequently exist the need of additional slime control agents. For example, during periods of contamination of the cooling water by reducing agents, chlorination facilities may be inadequate for the quantity of chlorine required under these circumstances.



Heavy slime formation in heat exchanger.

Addition of agents such as the chlorinated phenols or the various commercial combinations, may be necessary to control organic growths during such periods. Even where the increased chlorine dosage can be handled by the feeding equipment installed, it may be more economical to use another slime control agent at such times rather than to employ the greatly increased amounts of chlorine required during periods of contamination.

At the present time, there is no single toxic agent which is completely effective for the control of biological fouling in all types of industrial cooling water systems. There are faults inherent in all of the toxicants in common use. Chlorine is highly effective and rapid in bactericidal action, but chlorine consumption is greatly increased by the presence of reducing agents.

In addition, chlorine residuals can and often do have an adverse effect on cooling tower wood—particularly when residuals on the order of 1 ppm or higher must be maintained. Chlorine reacts with the lignin components of the wood and produces a bleached, fibrous surface. The cascading water readily washes away the weakened surface layers of the wood. With time the wood becomes thin and loses much of its strength. There is evidence that towers that use chlorine alone for slime control are more susceptible to fungus attack of the wood. Extensive damage from fungus attack is not uncommon and has been responsible for costly tower repairs and maintenance.

The chlorinated phenols and other materials may present a problem of fish toxicity in the blowdown discharge. Copper salts are more specific to algae than to bacteria and are rendered ineffective by precipitation at higher pH values. Quaternaries are affected by ions and organic matter.

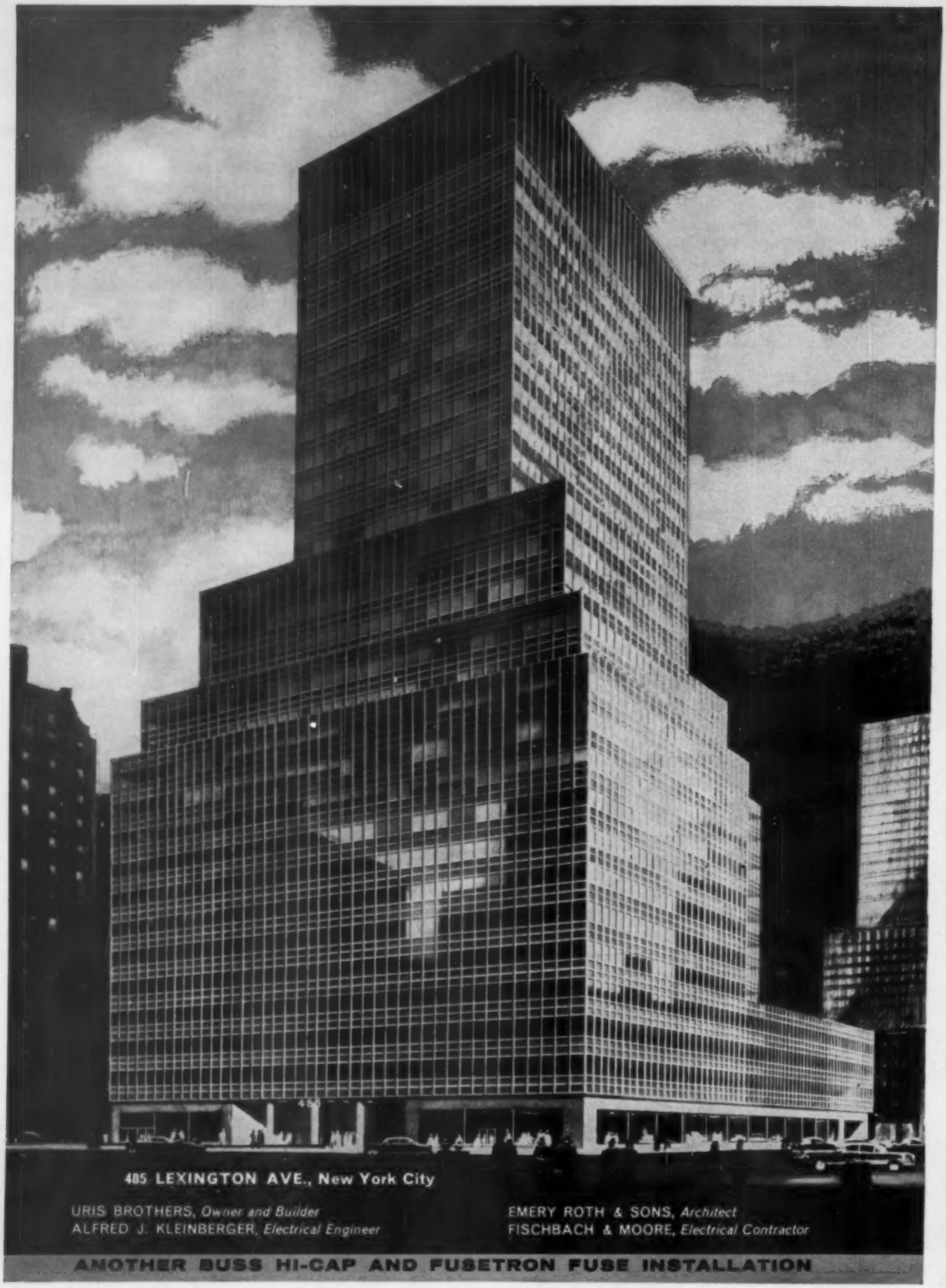
All of these chemical agents are not equally economical and efficient. Selection of toxicants must be based on the microbiological complex encountered. Frequently, more than one toxicant is desirable to control, for example, both a bacteriological slime and/or algae problem. Methods and frequency of chemical feeding must be varied to suit the individual problem. Slime control agents vary in the rapidity of their action and must be selected with a knowledge of the retention period in the system. Compatibility of the toxicant must be studied in relation to other treatments used for scale and corrosion control. Local conditions governing discharge of blowdown water from the cooling system must be considered. Selection of the proper method of control of microorganisms in cooling water systems requires evaluation of numerous factors.

AND ALGAE

A complete and detailed study of biological fouling in recirculating cooling water systems is available in Betz Technical Paper No. 134A. We will be pleased to send you a copy.

BETZ LABORATORIES, INC.
Gillingham & Worth Streets • Phila. 24, Pa.

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS



485 LEXINGTON AVE., New York City

URIS BROTHERS, *Owner and Builder*
ALFRED J. KLEINBERGER, *Electrical Engineer*

EMERY ROTH & SONS, *Architect*
FISCHBACH & MOORE, *Electrical Contractor*

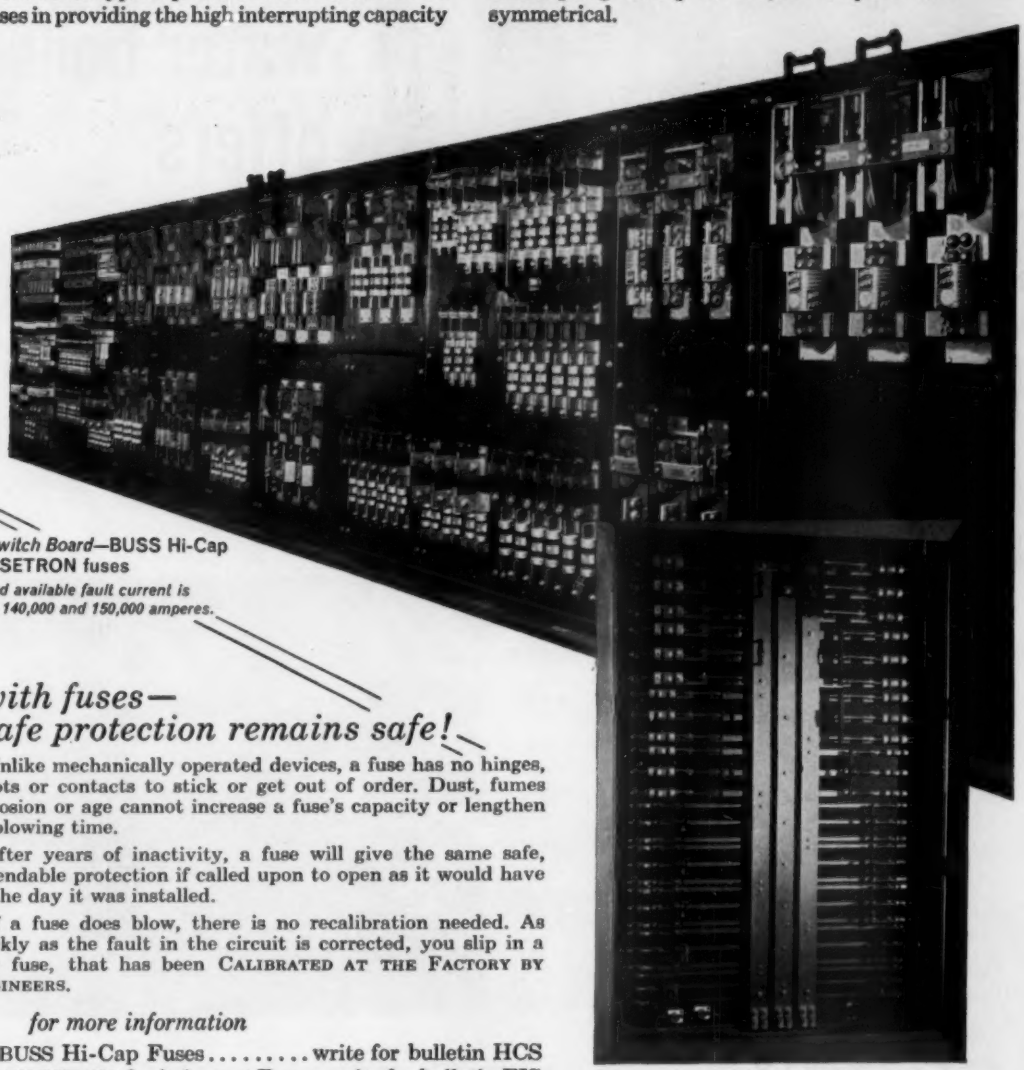
ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION

Electrical Protection goes MODERN *with* BUSS Fuses at 485 Lexington Ave., New York, N.Y.

In keeping with the modern trend the electrical protection for this new 30 story office building is BUSS Hi-Cap and FUSETRON dual-element fuses.

No other type of protective device can match fuses in providing the high interrupting capacity and dependability required for today's circuits.

BUSS Hi-Cap fuses have a NEMA interrupting rating of 200,000 amperes rms symmetrical. FUSETRON dual-element fuses have a NEMA interrupting rating of 100,000 amperes rms symmetrical.



Main Switch Board—BUSS Hi-Cap *and* FUSETRON fuses

Estimated available fault current is between 140,000 and 150,000 amperes.

with fuses— safe protection remains safe!

Unlike mechanically operated devices, a fuse has no hinges, pivots or contacts to stick or get out of order. Dust, fumes corrosion or age cannot increase a fuse's capacity or lengthen its blowing time.

After years of inactivity, a fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

If a fuse does blow, there is no recalibration needed. As quickly as the fault in the circuit is corrected, you slip in a new fuse, that has been CALIBRATED AT THE FACTORY BY ENGINEERS.

for more information

On BUSS Hi-Cap Fuses.....write for bulletin HCS
On FUSETRON dual-element Fuses..write for bulletin FIS

Distribution Panels
PROTECTED BY FUSETRON FUSES

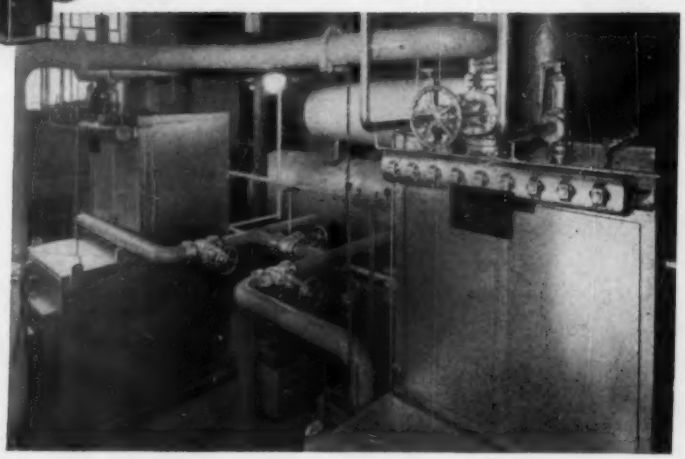
BUSSMANN MFG. DIV., McGRAW-EDISON CO., ST. LOUIS 7, MO.

For more data circle 511 on Post Card

In new plants large and small...

The C-E high temperature water boiler offers savings of 10 to 20%

Shop assembly view showing steel frame and pressure parts for 25-million Btu unit prior to installation of refractory, insulation block, and welded gastight casing.



Compactness of C-E HCC Boilers is demonstrated in this view of two 10-million Btu units installed at a new Michigan high school.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

C-190

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS, FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

The list at right points up the versatility and widespread acceptance of Combustion Engineering's HCC boiler. For industrials, schools, institutional use, military bases—wherever there is extensive space to be heated—C-E high temperature water has a place.

Featuring the same principle applied by Combustion in many of its large utility boilers, the C-E LaMont Controlled Circulation Hot Water Boiler offers a compact and effective arrangement of heating surfaces. This design gives precision temperature control, and, dependent upon local conditions, the HCC can save 10 to 20 per cent in maintenance and operating costs—a significant factor when considering a heat source.

Available in a wide capacity range—from 10 to 300-million Btu's—these boilers operate at water pressures up to 500 psi and temperatures to 470 F or higher. The smaller capacity HCC's are completely shop-assembled, while the intermediate and large units are shipped in varying stages of assembly. This C-E practice greatly reduces erection costs.

If you are in the market for boilers, either for space heating or process requirements, it may prove greatly to your advantage to investigate C-E high temperature water as your heat source.

Because individual needs vary, *both* steam and hot water have their applications. Combustion Engineering can furnish either, and our engineers are exceptionally qualified to discuss *impartially* with you or your consultants the method most suitable for your situation.

Write for further details on Combustion Engineering's High Temperature Water Boilers.

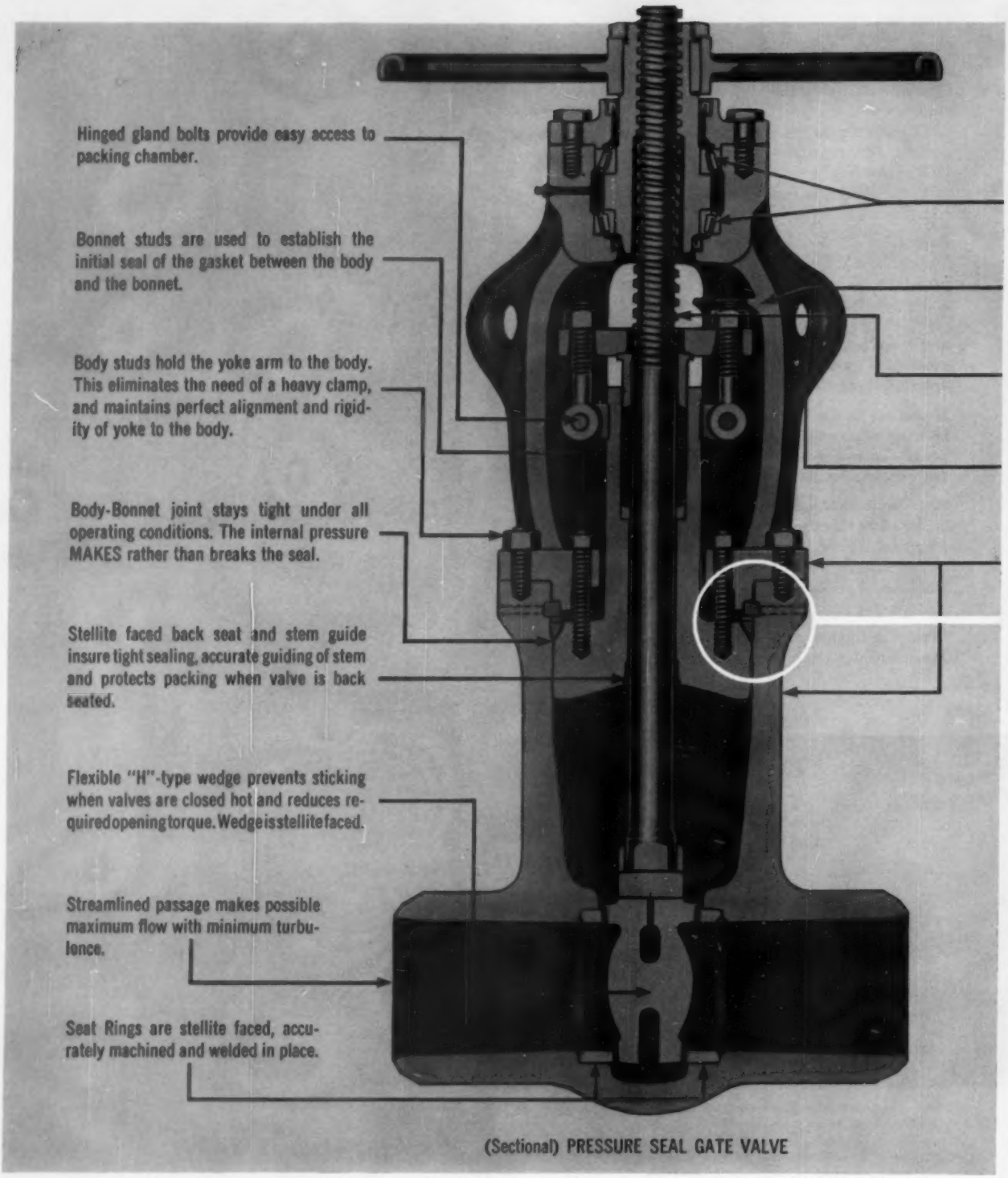
Representative list of C-E HCC Boilers in service, under construction, or on order

	No. of Units	Normal Output ea.—Btu/Hr. (millions)	How Fired
A. E. Smith High School Riverview, Michigan	2	10	Oil
J. Bishop & Co. Malvern, Pa.	1	12	Oil
Colorado State College Greeley, Colo.	1	60	Oil— Nat. Gas
Cross Company, The Frazer, Michigan	2	12	Nat. Gas— Oil—
Defense Construction Ltd. Camp Gagetown, N. B., Canada	3	70	Pulv.Coal— Gas
Erie Mining Company Aurora, Minn.	2	65	Stokers— Oil or Gas
Convair Astronautics Div. General Dynamics Corp. San Diego, Calif.	2	30	Oil— Nat. Gas
General Motors Overseas Santos, Brazil	1	12	Oil
Hillcrest Medical Center Tulsa, Oklahoma	1	30	Nat. Gas
Marquardt Aircraft Co. Ogden, Utah	2	12	Oil— Nat. Gas
Michigan State University Oakland, Michigan	1	12	Oil— Nat. Gas
New Florida State Prison Raiford, Florida	2	30	Oil— Nat. Gas
North Carolina Wesleyan College Rocky Mount, N. C.	2	18	Oil— Nat. Gas
U. S. Air Force Academy Colorado Springs, Colorado	3 2	100 30	Oil— Nat. Gas
U. S. AIR FORCE: Clinton County Air Force Base Wilmington, Ohio	1	18	Stoker
Dover Air Force Base Dover, Delaware	3	50	Oil— (Fut. Coal)
Forbes Air Force Base Topeka, Kansas	3	42	Oil— Nat. Gas (Fut. Coal)
Grand Forks Air Force Base Grand Forks, North Dakota	2	25	Stokers— Oil
McGuire Air Force Base Wrightstown, N. J.	4	80	Stokers
Minot Air Force Base Minot, North Dakota	2	25	Stokers— Oil
Plattsburgh Air Force Base Plattsburgh, N. Y.	2	50	Oil
Portsmouth Air Force Base Portsmouth, N. H.	2	110	Oil— Nat. Gas (Fut. Coal)
Wright-Patterson Air Force Base Dayton, Ohio	1	30	Stoker
Wurtsmith Air Force Base Oscoda, Michigan	2	25	Stokers
Air Force Base Torrejon, Spain	3	43	Oil
U. S. Navy Auxiliary Air Station Fallon, Nevada	2	15	Oil

One of the many large plants using C-E High Temperature Water Boilers is Convair-Astronautics Division of the General Dynamics Corporation. Installed at this new $40-million center for Atlas Intercontinental Ballistic Missile research, development, manufacture, and primary testing are two 30-million Btu HCC Boilers.

For more data circle 512 on Post Card

ADVANTAGES OF **POWELL**


Hinged gland bolts provide easy access to packing chamber.
Bonnet studs are used to establish the initial seal of the gasket between the body and the bonnet.
Body studs hold the yoke arm to the body. This eliminates the need of a heavy clamp, and maintains perfect alignment and rigidity of yoke to the body.
Body-Bonnet joint stays tight under all operating conditions. The internal pressure MAKES rather than breaks the seal.
Stellite faced back seat and stem guide insure tight sealing, accurate guiding of stem and protects packing when valve is back seated.
Flexible "H"-type wedge prevents sticking when valves are closed hot and reduces required opening torque. Wedge is stellite faced.
Streamlined passage makes possible maximum flow with minimum turbulence.
Seat Rings are stellite faced, accurately machined and welded in place.

(Sectional) PRESSURE SEAL GATE VALVE

POWELL...world's largest family of valves

PRESSURE SEAL VALVES!

Pressure Classes...600, 900, 1500, 2500 Pounds and Higher... ALL COMMERCIAL SIZES

Pressure Seal Gate Valve

Tapered roller bearings are most satisfactory for high thrust loads.

Lugs on the inner side of yoke arms provide a convenient shelf for suspending gland when renewing packing.

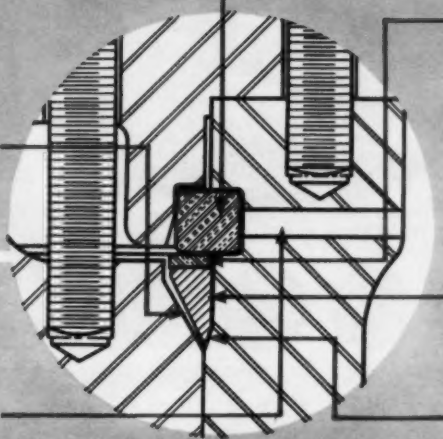
Accurately ground stem threads reduce friction and prolong the life of the stem and bushing.

Lifting lugs facilitate handling the valve during erection and maintenance. Also provide means for supporting weight of the valve.

Streamline contour of body simplifies application and reduces cost of insulation, and effects marked savings in space and weight.

Segmental thrust rings absorb all the thrust applied by internal pressure. This design enables valve to be easily assembled and disassembled.

A hardened stainless steel protective ring prevents deformation of the top surface of the soft metallic gasket.



A differential angle between gasket and bonnet assures line contact.

The gasket may be removed without damaging the sealing surface of the body. As the gasket is removed, the sealing surfaces separate freely without damage to gasket seat in body.

By inserting knock-out pin in drilled hole segmental thrust ring can be easily driven out of retaining groove.

The gasket seating surface in the body may be easily lapped, if required — an outstanding feature in Powell Pressure Seal Valve design.

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HELPFUL BULLETINS

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Cards provided on pages 125 and 126.

VALVES AND FITTINGS

101 Valves at a Glance — This automatic valve wall chart features ready reference data on company's varied line of hydronic controls, relief valves, pressure regulators and safety devices. Chart is produced the same size as a standard file folder and opens to full 12 by 18 in. A. W. Cash Valve Mfg. Corp.

102 Solenoid Valves — Listed in 36-pp Catalog 444 is a line of solenoid valves of bronze and stainless steel construction. Detailed valve specifications, performance data, specific application information and other features are included in the catalog, as well as cutaway views and diagrams. Atkomatic Valve Co., Inc.

103 Hydraulic Operating Valves — Featured in 20-pp Reference Book 39-6 are hydraulic operating valves offering economy of operation and other advantages. Dimensional data and diagrams, capacity charts, piston speed and flow charts are included. Homestead Valve Mfg. Co.

104 Acid Resistant Valves — Eight-pp Technical Bulletin 8 describes an austenitic stainless steel for valving sulfuric acid and other corrosive liquids. Cross-sectional views show valve designs available and a graph illustrates strengths and temperatures of sulfuric acid in which alloy may be used. Alloy Steel Products Co., Inc.

105 Control Valves — Bulletin 300 describes a three- and four-way control valve designed for a variety of rugged control applications. Wash drawings of cut-away views and diagrams explain operating principle and design features and table gives specification data. W. H. Nicholson and Co.

106 Oil Valves, Fittings — Catalog B-159, 58 pp, details a broad line of valves and fittings for the petroleum industry. Includes bronze and aluminum valves and accessories — nozzles, fill caps, gate valves, cross and check valves, line strainers, others. Book is well indexed for easy reference, provides engineering data. Milwaukee Valve Co.

107 Pipe Fittings — Steel and brass fittings for flexible plastic pipe are listed in Sheet MF107. Gives sizes, weights, prices for adapters, couplings, ells, tees and clamps. Campbell Mfg. Co., Inc.

108 Universal Joints — Catalog C4-10M contains 10 pp of detailed information on single and double universal joints. Includes assembly data, specifications, conversion table and decimal equivalents. Curtis Universal Joint Co., Inc.

HEAT TRANSFER

109 Heating Equipment — Bulletin 581 describes a line of heat transfer products, including hairpin heat exchangers; fired indirect heaters for heating air, gases, chemicals, oils, asphalts, superheating steam and other vapors; tank heaters and coolers for bulk heating of gaseous or liquid materials; and packaged boilers. Brown Fintube Co.

110 Heat Exchangers — Specification Manual M-100 is a 10-pp guide to double pie or hairpin heat exchangers. In addition to general specifications, there are sections on design, materials, welding procedure, testing, inspection and stamping, as well as assembly drawings. Brown Fintube Co.

111 Aluminum for Heat Exchangers — Advantages of aluminum usage in heat-exchanger fabrication are described in this 16-pp bulletin. Text covers aluminum heat transfer rates, temperature properties, tensile strengths, pressures and dimensional tolerances. Charts provide information on aluminum stress values, working pressures, thermal expansion and conductivity and friction factors. Reynolds Metals Co.

MECHANICAL POWER TRANSMISSION

112 High-Torque Transmissions — This 32-pp engineering data booklet describes transmissions and reduction gears with input torque capacities ranging from 120 to 2400 ft-lb. Includes detailed engineering drawings, specifications, including capacity, gear ratios, and variations available for all standard units. Cotta Transmission Co.

113 Flexible Shafts — Bulletin 590 contains design data on a high speed flexible shaft designed to transmit rotary motion over a curved path. Dimensions and specifications are included. Stow Mfg. Co.

114 Motor Gear-Reducer — Illustrated and described in 28-pp Bulletin 3100 are all-steel, helical gear reducers with standard NEMA motors. Includes detailed information on unit size and construction, typical installations, data on accessories, suggestions for unusual or special applications, and specifications and dimensional data. The Falk Corp.

115 Worm Gear Reducers — Folder 2724, 8 pp, introduces a worm gear speed reducer designed to operate in three positions, which offers higher capacity, and is available from stock. Shows various mounting positions and gives selection procedures for proper applications. Tables cover service factors, load classes, input horsepower ratings, load ratings. Dimensions and weights included. Link-Belt Co.

116 Screw Conveyor Drive — Featured in 16-pp Bulletin A667C is a screw conveyor drive complete with speed reducer, packing gland and drive shaft, all of which mount as a unit on a trough end. Includes photos, engineering drawings with dimensions, prices, and tables to facilitate selection of units and V-belt drives for various loads and speeds. Dodge Mfg. Corp.

117 Adjustable Speed Drive — Six-pp Bulletin 2750 describes features and applications of an adjustable speed drive which utilizes a stationary field construction to eliminate brushes, commutators and slip-rings. Dimensions, engineering data and a cutaway view are included. The Louis Allis Co.

118 Stock Sprockets — Selection and ordering information on Grip-Master hub type and plate type sprockets, off the shelf and ready for use, is presented in 20-pp Catalog 100 B. Illustrated with photos and dimension drawings, catalog also gives data on flexible roller chain couplings, roller chains, plates and weld-on hubs. Acme Chain Corp.

119 Bearing Units — Illustrated and described in 16-pp Bulletin BU-101-B is a line of take-up units combining advantages of anti-friction bearings with unbreakable malleable housing, and rugged welded steel take-up frames with cadmium plated adjusting screws. Details of construction, dimensional tables and listing of stock sizes included. Browning Mfg. Co.

120 For Conveying, Transmission — Featured in this 8-pp bulletin is a complete selection of rubber, Neoprene and Hycar belting for conveying and power transmission. Specification data table is included. Voss Belting & Specialty Co.

PUMPS

121 Proportioning Pump — Bulletin Ref. No. 1106.20A-1 describes a proportioning pump for general industrial fluid use. Design features are illustrated and described, and a capacity table is included. B-I-F Industries, Inc.

122 Submersible Pump — Features and advantages of a submersible, portable electric pump are illustrated and described in this 6-pp bulletin. Applications are detailed and capacity curves and other engineering data given. Stenberg Mfg. Corp.

123 Industrial Pumps — Centrifugal and rotary pumps for a wide range of industrial uses are illustrated and described in this 72-pp catalog. Featured are open-impeller centrifugal pumps, in both sealed and seal-less types, and mechanical positive-displacement rotary pumps, as well as pumps designed for special conditions of temperature, viscosity, specific gravity, lubricating characteristics, chemical properties, contaminants and abrasives. Detroit Harvester Co.

INSTRUMENTS, CONTROLS

124 Renting Instruments? — Eight-pp Bulletin GEA-6829 describes this company's nationwide instrument rental program. Covers scope of program and other factors involving more than 13,000 instruments offered for rent, including recording instruments, oscillo-

graphs, leak detectors, voltmeters, pyrometers. General Electric Co.

125 Supervisory System — Bulletin GET-2925, 8 pp, describes application and operation of automatically programmed remote indication logging system designed to operate in conjunction with its space-code selector supervisory equipment. Includes information on coding; master and remote station components; adding to existing systems; physical arrangements, control power, operating voltages and channels; and includes photos, diagrams of basic components, code charts, schematic diagrams. General Electric Co.

126 Centralized Controls — Bulletin 159 illustrates and describes various custom-engineered control panels combining a wide range of sequencing, supervising, indicating and power controls for industrial processes, machine automation, and heating applications. Describes advantages of centralized control. Protection Controls, Inc.

127 Level, Flow Control — Operating and safety controls for a variety of jobs involving liquid level and liquid flow are described in 24-pp Bulletin ERS-A. Featured are float-operated valves and switches and flow switches, with typical application stories, schematic drawings, electrical wiring diagrams and engineering data. McDonnell & Miller, Inc.

128 Electronic Thermometer — Bulletin B describes applications of these electronic thermometers on various surfaces, liquids, air and gases, rubber and plastic masses in a wide variety of industries. Lists individual temperature ranges for various models and includes specifications such as speed of response, reproducibility, accuracy, size, weight and power. Atkins Technical, Inc.

129 Combustion Control — Diagrammatics of typical combustion control systems as applied to a stoker-fired boiler are given in Bulletin 515. Both chain-grate and spreader type stokers are covered, along with a discussion of steam pressure and steam flow-air flow measurement. Bailey Meter Co.

130 Recirculation Control — A pump recirculation control system to maintain safe, adequate pump flow at all times is described in Bulletin 560. Both pneumatic and electric systems for increasing pump flow by recirculation are shown. Bailey Meter Co.

131 Btu Meter — Full information and specifications on company's Btu meter designed to continuously record, indicate and integrate Btu loss or gain of a flowing liquid are presented in this product specification sheet. Schematic illustrates details. The Hays Corp.

132 Oxygen Meter — Description and details of operation of this dissolved oxygen meter are given in three product specification sheets. A system schematic is included, as well as other illustrative material and data. The Hays Corp.

133 Gas Analyzers — Described in 12-pp Publication 55–668–27 is a line of gas analyzers for industrial and scientific gas measuring. Specifications are included. The Hays Corp.

134 Colorimetric Analyzer — Featured in Bulletin 858 is an automatic colorimetric analyzer for determinations of water hardness, pH, residual chlorine, phosphate, hydrazine and dissolved iron concentration. Describes design features and operation, and includes specifications. Milton Roy Co.

135 Colorimetric Analysis — Eight-pp Bulletin 1156-1 describes industrial instruments available for colorimetric determinations of trace quantities of substances dissolved in liquid process streams. Gives details on analyzers for dissolved silica, dissolved oxygen and total water hardness, and includes schematic diagrams. Milton Roy Co.

FANS, AIR DIFFUSION

136 Induced Draft Fans — Bulletin L-3, 16 pp, describes advantages of company's induced draft fans and illustrates unique features. Dimensioned drawings and charts are presented, also instructions covering ordering procedures. Schematic diagrams of installations included. Lehigh Fan & Blower Div., Fuller Co.

137 Air Diffusion Equipment — Catalog 1–59 is a comprehensive 56-pp publication for easy selection of all types of air diffusion equipment. A feature is a color-key for identification at-a-glance of four major product groups, covering wall and ceiling type supply grilles and registers; wall, ceiling and door type return grilles and registers; extruded aluminum grilles; and accessories such as volume extractors and plaster frames. Detailed selection tables and illustrations are included. Waterloo Register Co., Inc.

138 For Air Handling — Sixteen-pp Bulletin 518 illustrates and describes manufacturer's products for air filtering, cooling, heating, cleaning (controlling process dust), moving, exhausting, humidifying and dehumidifying air. These include Kennard, Herman Nelson, Illinois Engineering and American Air Division product lines. Fully illustrated, booklet provides brief application suggestions, capacity data. American Air Filter Co., Inc.

ELECTRICAL

139 Synchronous Generators — Bulletin GEA-6815 describes design features, construction and applications of company's high-speed synchronous generators. Illustrations show manufacturing techniques and typical installations. General Electric Co.

You'll save time in ordering bulletins by using the Reader Service Cards on page 125. Of course we honor letterhead requests—but it takes us somewhat longer to handle them.

140 Distribution Transformers — Bulletin GEA-5683A describes company's oil-filled, single-phase, pole-type conventional and self-protected transformers for industrial and other lighting applications. Includes detailed rating information. General Electric Co.

141 Dry-Type Transformers — Eight-pp Bulletin GEA-6668A describes open dry-type transformers featuring inorganic insulation to add to transformer life. Installation and maintenance information outlined and electrical, mechanical features charted. General Electric Co.

142 Multi-Conductor Cable Polyvinyl-insulated, multi-conductor cable for installing six to 56 pairs of thermocouple wires at one time is described and illustrated in Catalog 33. Advantages are detailed, and specifications, resistance chart, and electrical properties table included. Thermo Electric Co., Inc.

143 Guide to Millivoltmeters — Operating principles, specifications, features, and ordering information on non-control and control millivoltmeters are presented in 28-pp Catalog C 10–1. Dimensional diagrams and photos included. Minneapolis-Honeywell Regulator Co.

144 Pushbutton Stations — Corrosion resistant surface mounted pushbutton stations and pilot lights designed to operate under toxic conditions are described in Bulletin 14B7814B. Features and applications are detailed, and ratings and dimensional diagrams included. Allis-Chalmers Mfg. Co.

145 For Corrosive Spots — Sixteen-pp Bulletin 2699 on Condulets for corrosive locations discusses corrosion-resistant properties of a variety of metals and finishes utilized. Charts show applications of each. Also provides formal listings of Plast-A-Coat Condulets for hazardous and non-hazardous locations. Crouse-Hinds Co.

146 Electromagnetic Devices — Sixteen-pp Bulletin GEA-6675 describes Selsyn and Synchro electromagnetic devices for accurate transmission of electrical angular data between two or more points. Discusses Selsyn and Synchro generators, motors, control transformers, differential generators, differential motors, tandem Selsyns, and system operation, and includes schematic and line drawings and dimensions. General Electric Co.

147 Lightning Arresters — Eight-pp Bulletin LA6 describes secondary class lightning arresters and primary protective gaps. Includes application data and ordering information along with operating and design features. Line Material Industries.

148 For Rewound Motors — Eight-pp Booklet B-7622 describes a solventless epoxy encapsulation-type insulation for rewound motors. Outlines physical and chemical properties and describes typical applications. Westinghouse Electric Corp.

149 Electrical Insulation — Twelve-pp Bulletin GET-2929 describes in text, tables and pictures the characteristics and application range of insulating materials for electrical systems. Includes data on mica mat, varnished cloths and papers, insulating varnishes, wire enamels, irradiated polyethylene, sealing and filling compounds, insulating finishes and adhesives. General Electric Co.

150 Readout Lamps — This booklet describes a line of electroluminescent devices for the display of letters and numerals in various types of dials and indicators in readout equipment. Applications and features are illustrated. Westinghouse Electric Corp.

FIRE PROTECTION

151 Fire Extinguishers — This folder contains a table comparing characteristics of various types of fire extin-

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Flexonics has the equipment – as well as the experience and the skill – to take care of any kind of pipe motion problem. Here's where you benefit from more research . . . more metallurgical care . . . more service . . . and now standard stock sizes for quick delivery from Flexonics warehouses. They all add up to expansion joints that you can *install and forget* – plus expansion compensators, flexible connectors, and the all-new Flexonics pipe alignment guides–to take care of any kind of pipe motion!

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Ideal for Hospitals, Hotels, Apartments, and Industries where noise is objectionable.

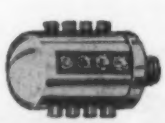
Rotojet Electric Tube Cleaner thoroughly cleans straight tubes from 25/32" to 4" I.D. in boilers, condensers, evaporators, and heat exchangers so quietly that it can be operated without disturbing anyone.

This self-contained unit comprises a powerful motor, rotatably mounted on a stand, a required length of heavy duty flexible shaft, a 20 ft. cable, and a selection of heads, brushes, drills, and scrapers to meet any cleaning need. The motor swivels and rotates so that tubes on top, bottom, and sides can be cleaned without moving the unit. A few of the many types of heads available are shown below.

Bulletin 107 gives full details of this quiet, efficient, convenient tube cleaner. Send for it now.

Rotojet Electric Tube Cleaner with swing-frame head.

4-way drill and universal coupling.



Expanding wire brush.

ELLIOTT COMPANY – ROTO PLANT
Tube Cleaner Specialists Since 1910

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For more data circle 516 on Post Card

guishers. A bar graph shows the comparative effectiveness of extinguishing agents. Ansul Chemical Co.

152 Extinguishing Equipment — This 6-pp brochure describes portable fire extinguishers and accessories. Among the types described are carbon dioxide, dry chemical, soda-acid, foam, vaporizing liquid, pressurized water and anti-freeze extinguishers and wheeled engine units. American LaFrance Corp.

INSULATION

153 Styrofoam Covering — Twelve-pp Bulletin 157-57 covers Styrofoam pipe and vessel covering applications for low temperature insulation. Generously illustrated, booklet presents a variety of engineering data, recommended application techniques and charts on recommended thicknesses and heat gain. The Dow Chemical Co.

154 Pipe Insulation — Described in this company publication is the application of Gilsulate pipe insulation in the underground piping system of a large research center. Photos showing construction and installation details are included, as well as data on nature and uses of Gilsulate. Gilsulate Div., American Gilsonite Co.

OTHER EQUIPMENT

155 Condensate Filtration — Technical Reprint T-172 contains an 8-pp discussion of filtration of condensate as part of the high rate condensate scavenging process. How filtration is being used in connection with scavenging at various power plants, including supercritical, nuclear and monotube boiler installations covered. Graver Water Conditioning Co.

156 Rubber Seals — This 24-pp Fact Book provides selection and installation information on company's Quad-ring and O-ring seals. Diagrams showing details of design are included, as well as specifications and information about media in which various rubber compounds can be used. Minnesota Rubber Co.

157 Chromate Test — A test for chromate which eliminates liquid reagents except the usual sodium thiosulfate is described in this analytical data sheet. Complete details for various ranges are given. Betz Laboratories, Inc.

158 Heat Transfer Cement — Six-pp Bulletin 300 describes a heat transfer cement which eliminates the need for jacketed equipment. Describes advantages and properties of the material and illustrates applications. Thermon Mfg. Co.

159 Coating Structural Steel — These four recommendation bulletins were created to aid in preparing specifications for coating steel surfaces. Bulletins cover: Specifications for coating galvanized iron surfaces, coating steel water tanks, coating metal window sash, and coating structural steel. Rust-Oleum Corp.

160 Welding Guide — This 32-pp, pocket-size welding guide describes stainless, low-alloy, non-ferrous rods and electrodes for manual, automatic, and semi-automatic welding. Products are listed in chart form, along with such information as forms available, description, welding applications, AWS-A TM designations, popular name type, heat treatment data for maximum properties, pre-heating data, and tensile properties. Arcos Corp.

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CALL YOUR *FISHER/MAN*

Screwed-in seat rings are Stellite faced to eliminate erosion and wire drawing. Fisher seal welds them in place to keep rings from working loose and to prevent leakage past the threads.

CALL YOUR *FISHER/MAN*

Available in single or double ported body designs—one and two inch sizes in the single ported and two, three and four inch sizes in the double ported design.

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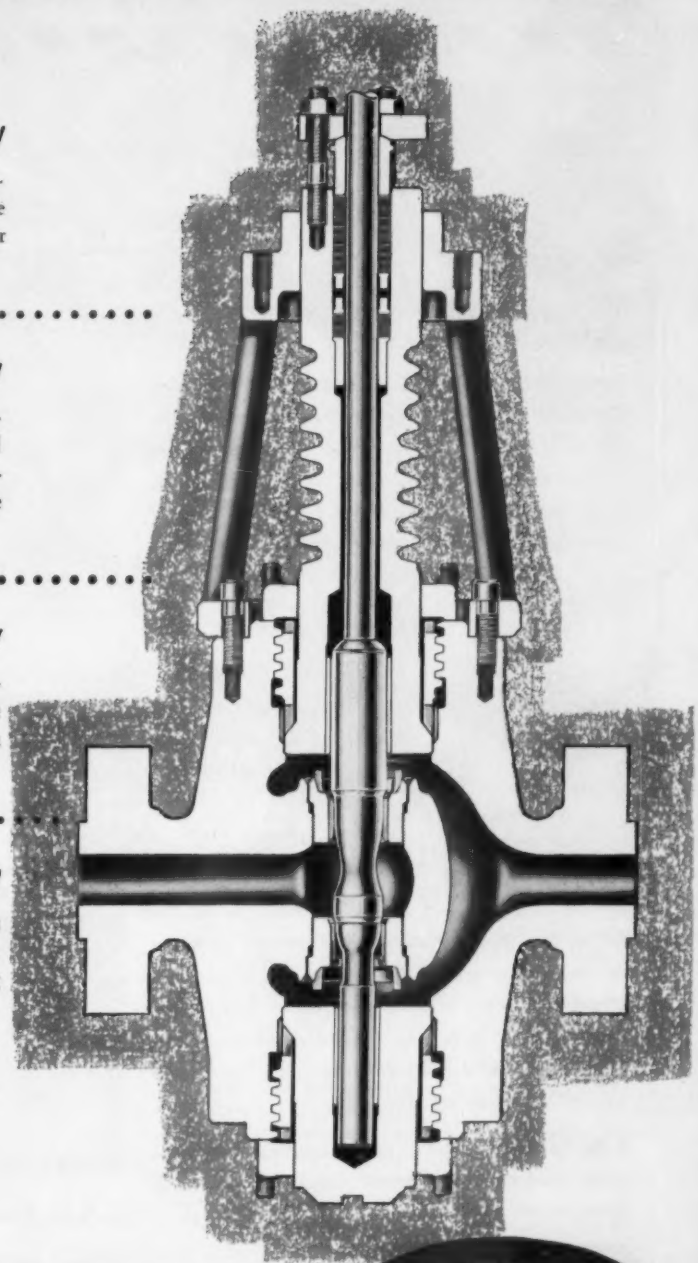
Use of a pressure sealed bonnet eliminates need for heavy, cumbersome flange heads. Head construction with or without cooling fins is available.



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The Chemical Treatment of Boiler Feed Water. This technical bulletin contains a clear explanation of the causes of boiler water problems and Western's methods of solving them. Special emphasis on scale prevention, corrosion control, sludge dispersion, and suppression of foaming and carry-over.

Steam Plus CORAVOL Equals Protection From Corrosion. This technical bulletin tells how CORAVOL, the original amine process, gives complete protection from corrosion to your entire steam-condensate circuit. Clearly explains the theory of corrosion and the application of volatile amines to steam systems. Cites typical case histories of the use of CORAVOL in various plants and industries.

The Chemical Treatment of Industrial Cooling Water discusses common cooling water problems—scale, corrosion, algae, slime. Also presents Western's proven methods for controlling and preventing these conditions in cooling towers, evaporative condensers, process heat exchangers, engine and compressor jackets, chilled water systems, etc.

Better Fuel Performance and Economy discusses the causes and effects of sludge in fuel oil supplies and soot deposits in combustion areas. Shows how these troubles can be eliminated economically, dependably, and permanently with time-tested special Western formulas.

Also, Technical Bulletins on the chemical treatment of potable and plant water supply—refrigerating brine—sweet water systems. Also, the use of Dry Acid Scale Removers.

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Whatever your water, steam or fuel treatment problem may be, you can rely on special Western formulas and individual technical service to solve it dependably and economically.

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161 Filing Equipment — Vertical and roll filing systems are illustrated and described in 12-pp Catalog 4-59. Design and construction details are shown and dimensional data given. Plan Hold Corp.

162 Glass Fiber Insulation — Characteristics and advantages of a blanket type glass fiber insulation are detailed in this product bulletin. Thermal and acoustical performance data is furnished. Mundet Cork Corp.

163 Filtration Facts — Entitled "Elementary my Dear Watson," or "The Case of the Hour-Glass Figure," this folder relates an interview between a lady-in-distress, Bella Cellulose, and Hairlock Sholmes, in which the heroine explains "the facts of life — engine life, that is." Technical explanation of filter condition called "hour-glassing" is covered. Engine Life Products Corp.

164 Nylon Stock Shapes — Property advantages of a material used to expand the field for nylon in such applications as gears, rollers, bearings, washers, wear strips and pads and other applications requiring long wear life and exceptional resistance to creep or cold flow are detailed in this bulletin on nylon shapes. The Polymer Corp. of Pennsylvania.

165 Nuclear Power Development — Featured in 28-pp Bulletin AEB-8 is detailed information on development, application or erection of power, propulsion, and research reactors as well as nuclear components. Summarizes company's activities in the nuclear field. The Babcock & Wilcox Co.

166 Servo Amplifiers — Eight-pp Bulletin S-961 describes high power transistor magnetic servo amplifiers for a variety of power control applications. Includes detailed engineering and performance data, as well as photos, diagrams and charts. Magnetic Amplifiers, Inc.

Bulletins reviewed here are offered primarily for qualified power engineers. Manufacturers may withhold literature from persons who do not state their job title and company. Some manufacturers also prefer not to send literature to those in foreign countries in which they have no sales representatives.

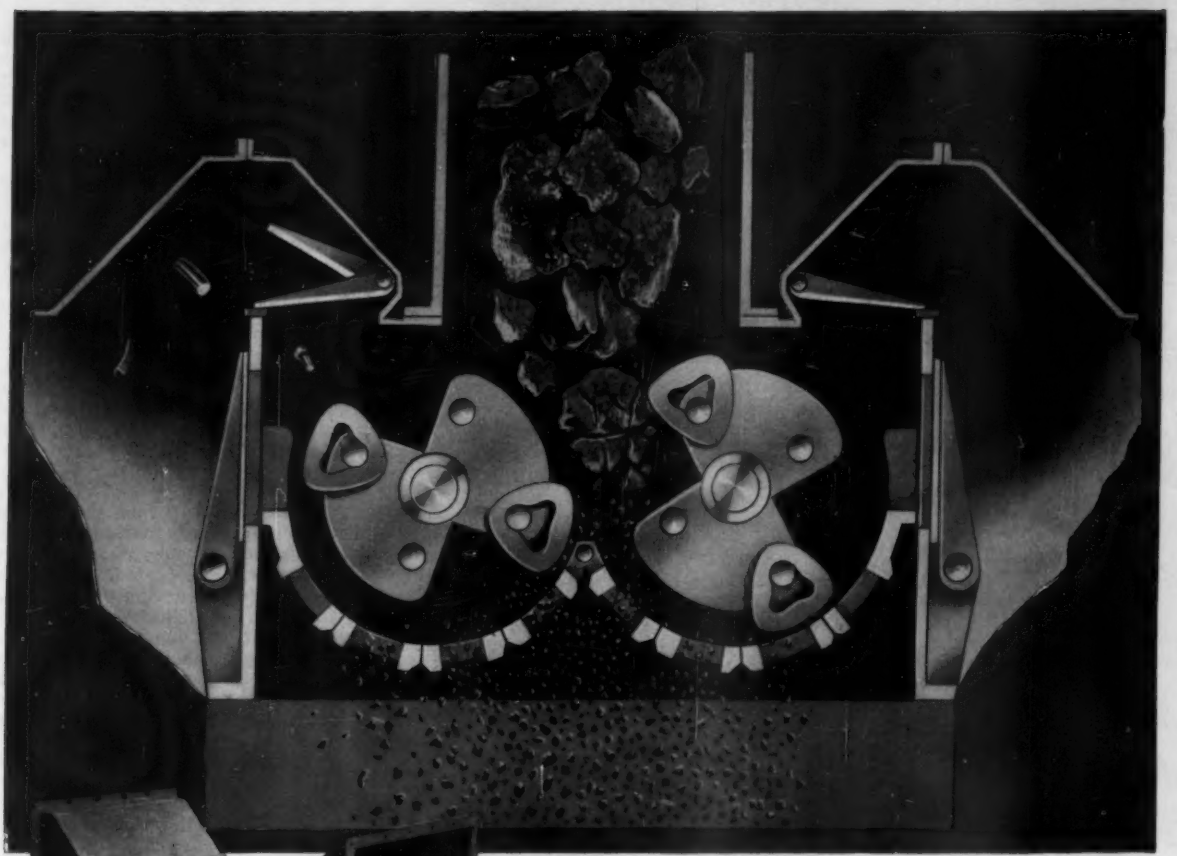
167 Calculating Machine — Featured in this 16-pp booklet is a tiny calculating machine with all four arithmetic operations. It can be held in one hand while being operated. Complete details on design and operation are given. Julian Benjamin.

168 Metal Spraying — Economy and effectiveness of metallizing for machine element work, corrosion/contamination protection, combination or high temperature coatings are discussed in 8-pp Reprint 19. Applications are fully described. Metalweld, Inc.

169 Automatic Lubrication — Advantages and economies of automatic lubrication systems are detailed in 16-pp Form 1-4428. Typical installations are illustrated and described, as well as various types of lubrication units, and section on operating characteristics and advantages included. Lincoln Engineering Co.

STEPHENS-ADAMSON

KNITTEL CRUSHER Ring Type with Double Rotor



Double Rotor Knittel Crusher with ring type double rotor.

DOUBLE ROTORS BLAST LUMPS TO SIZE WITHOUT DANGER OF PLUGGING

- EXCLUSIVE CRUSHING ACTION . . . Permits the material to fall further into the crusher where two sets of triangular sectors can take a high velocity direct blow on the suspended lumps. Lumps are not only shattered but are literally gobbled up in a continuous flowing stream to the sizing grates.
- CRUSHES DAMP MATERIALS with FULL CAPACITY . . . Eliminates the use of stationary breaker plates, as a result there is no plugging or choking and full capacity is maintained.
- LESS HEADROOM — LESS POWER REQUIRED . . . Requiring considerably less headroom and less power than with single rotor machines.
- TRIANGULAR SECTORS . . . Three wearing surfaces of manganese steel triangular sectors automatically position themselves to present the least worn surface to the crushing action.
- GRATE SIZING BARS . . . Provide accurate sizing of materials, prevent uncrushable materials from passing.
- AUTOMATIC TRAMP IRON RELEASE . . . Steel fingers, operating independently, automatically lift to pass uncrushable material.

WRITE FOR BULLETIN 858

S-A

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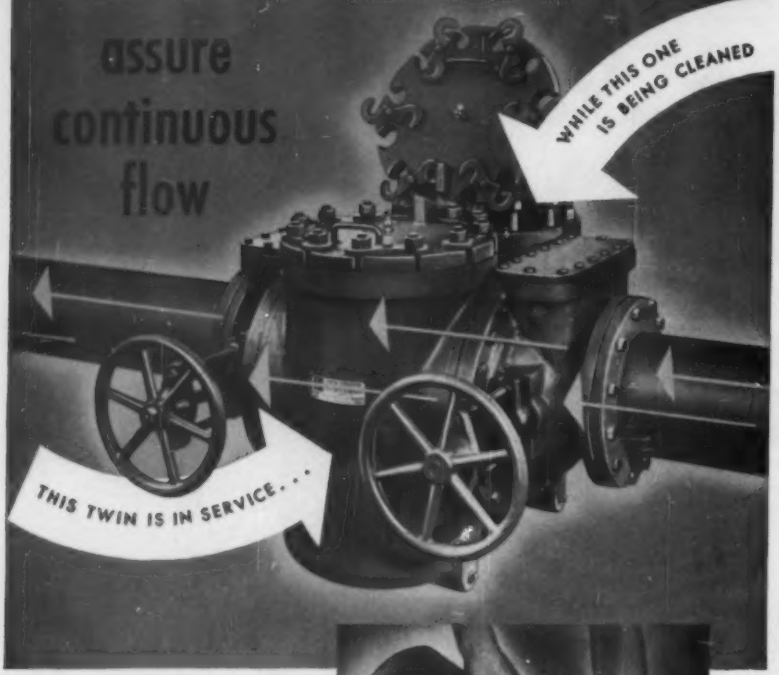
ELLIOTT

Twin Strainers

assure continuous flow



—provide "trouble-free" clean liquids

That's why Elliott Twin Strainers are so widely used by power plants and industry. They protect expensive liquid-handling equipment by straining liquids—without interrupting the flow. Shifting the flow from one strainer basket to another is accomplished easily by turning two valve wheels. Removing and dumping the strainer basket is simple. The result: the chance of objectionable solids gumming-up the works is eliminated.

The Elliott line of strainers also includes Single, and Self-Cleaning Strainers in sizes ranging from 1" to 24", and with straining perforations from 3/8" down to fine wire mesh. For further details contact your local Elliott District Office or write Elliott Company, Jeannette, Pa.

A7-2

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New Electronic Method Collects Test Data

NEW METHOD of collecting test data on hydraulic turbine models in Europe may well prove of great interest in this country.

Turbine research and model-testing laboratory, claimed by its owners to be among the best equipped in the world for testing models of hydraulic turbines, pump-turbines and pumps, has just been announced by the Swedish manufacturing combine Karlstads Mekanista Werkstad.

Located at that company's Kristinehamn works in central Sweden, the facility includes a high-pressure cavitation test tunnel and an open-flume circuit with 15-ft head for testing complete water power plant models with runner diameters up to 500 mm.

Largest single unit in the laboratory is the open-flume circuit. It is connected with a storage basin which, together with the discharge basin and channel, covers the entire basement area of the laboratory building. Storage basin holds 28,000 cu ft of water. Flume is 65-ft long and ends in a 24-ft deep pit to which the turbine model intakes are connected. Water level is kept constant through automatic control. Accurate flow measurement, vital to accurate testing, is taken by a "travelling screen," submerged, and made to run over a measuring distance of 13.12 ft. Running time is registered by a decade counter, while average depth of water is measured by a float level transducer.

Full coördination of all measurements of head and other levels, torque, axial force and the like is accomplished by means of contacts along the measuring distance. By pushing a button at the central control panel, the operator starts the screen carriage and all measurements required for a single test point are then automatically taken, indicated on the decade counters as average values, and read off or photographed by a robot camera.

Speed of the runner during test is registered by a tooth wheel on the runner shaft. Runner torque is measured with an indicating mechanical balance equipped with a scanner, the values obtained being transmitted to decade counters.

Actually, the decade counter installation is the "brain center" of the laboratory. It works with a time and frequency standard of 10,000 pulses per second from a crystal-controlled oscillator. Other electronic equipment in the laboratory includes a stroboscope for studying cavitation effects on turbines in motion.

Among jobs currently under development is design of the runner for a French tidal-water power project in Brittany. Karlstads Mekanista Werkstad is one of several firms working on this project. THE END

What you read is right

The new, patented Maxivision dial on American Bi-Metal Thermometers eliminates the perspective effect of usual pointer-above-dial construction. No parallax! Readings are sure, sharp and accurate – exact working temperatures are always right before your eyes. It is a two-level dial. A raised outer ring, set close to the cover glass, carries the graduations. The index type pointer is on the same plane as the outer ring, with the numerals on a lower level.

What you read is right when American Bi-Metal Thermometers with anti-parallax Maxivision dial are installed at important check points on your processing facilities. Mounting styles, dial sizes, temperature ranges and stem lengths are available to meet the most exacting requirements. Let your nearby industrial distributor help you select the best combination for each location.

American Bi-Metal Thermometer with Maxivision Dial. Suitable for indoor or outdoor service.

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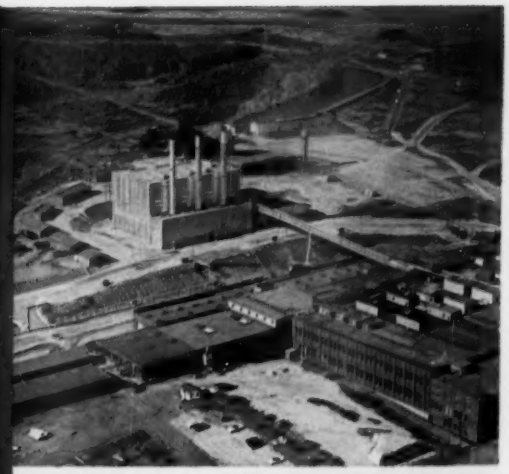
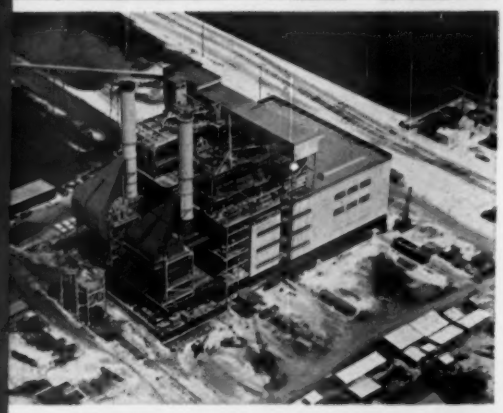
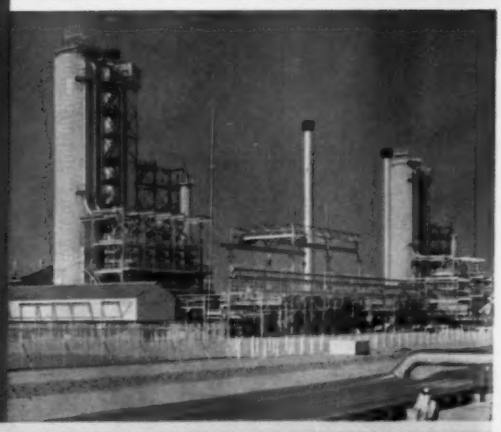
Atomic, hydroelectric and steam power, new plastics formed by molecular chemistry, new products from molded pulp and paper . . . these are some of the materials and forces that are reshaping our universe. These very same materials and forces are being produced today in plants designed and constructed by Stone & Webster.

Building today for tomorrow's needs has been Stone & Webster's objective for 70 years. The plants we build today must compete profitably with tomorrow's plants. This can only be achieved by reducing construction and operating costs . . . by scrupulously respecting client budgets and schedules.

If your company is contemplating expansion or actively planning new facilities, let us demonstrate how Stone & Webster's experience can add to your future profits. Call or write our nearest office.







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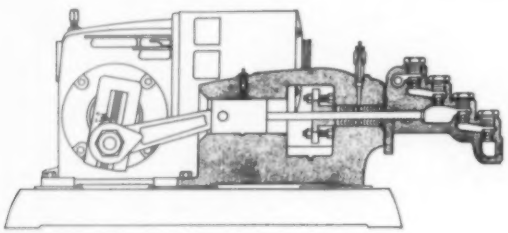
HOW TO METER ACIDS ACCURATELY AGAINST PRESSURE

Corrosive liquids present two major obstacles to achieving maximum metering accuracy, economy, and safety. For one thing, corrosion can introduce an intolerable ever changing volumetric error. For another, corrosive liquids must be retained by the pump at all times. Leakage can endanger personnel and necessitate the premature replacement of pump parts and associated equipment.

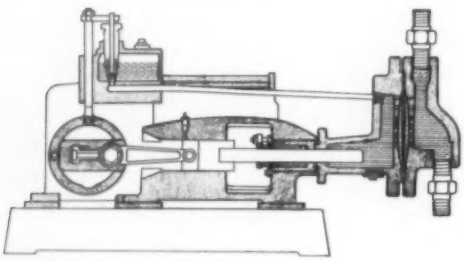
But both obstacles can be successfully overcome. First by choosing the right pump for the metering job at hand. Second, by making sure that all wetted parts of the pump chosen are inert to the liquid being metered. Here are some ideas based on practical acid metering experience that may help you to choose the one best controlled volume pump for your metering needs.



Packed Plunger Pumps

For the majority of mildly corrosive liquids, low cost packed plunger pumps have proved themselves entirely adequate. Some thirteen materials of construction are *standard* on packed plunger pumps, running from cast iron to Hastelloy B and C, more than enough to satisfy mild corrosive metering requirements. Capacities to 2056 gph, pressures up to 50,000 psi.

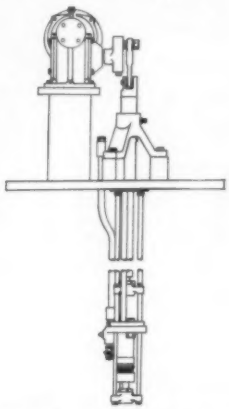
An added tip: Standard Milton Roy motor driven pumps in corrosive service can be equipped with "catch-all" yoke type gland followers.



Diaphragm Liquid Ends

When the liquid to be metered is highly corrosive or otherwise dangerous, a controlled volume pump with diaphragm liquid end is the best choice. A plastic or stainless steel diaphragm positively separates the process liquid and the plunger. The plunger displaces a hydraulic fluid which in turn strokes the diaphragm to create pumping action through the ball checks. Consistently high accuracy is achieved through unique design features. As the illustration shows, positive mechanical action bleeds any air or vapor from the hydraulic side between strokes and corrects liquid volume if necessary. Internal liquid end design also automatically eliminates bubbles from the process liquid side.

Very often, a pump chosen for mild corrosive service is obsoleted by a process change specifying a more highly corrosive liquid. But this waste is neither necessary nor desirable. The diaphragm liquid end illustrated can easily be substituted for the conventional liquid end on any standard motor driven controlled volume pump, bringing the entire metering system up to date at little extra expense. *Designs of this type will handle up to 400 gph against heads to 2700 psi.*



Totally Immersed Liquid Ends

Special metering problems demand special pump designs. For example, acids with high vapor pressure or high specific gravity must be pumped with limited suction lifts and generally require suction heads. The ideal answer is the standard Mersemetric® controlled volume pump. Pump drive and motor are mounted on the tank top, but the liquid end is completely submerged to a depth of up to fourteen feet. This same design feature also eliminates the need for tank connections below liquid level, and permits chemicals to be metered *directly* from storage.

The maximum safety-minimum handling Mersemetric design is just about standard for metering sulfuric acid for demineralizer regeneration and pH control of cooling tower water and deaerator effluents. *Capacities up to 218 gph, pressures up to 1200 psi.*

The Acid Metering System

You can be fairly sure of making the right choice only if you consider *all* the factors. Here's a convenient checklist of a few points that are often overlooked:

- Is the entire *system* corrosion-resistant . . . storage tank, suction and discharge piping, controlled volume pump, and relief valve?
- Have you thoroughly considered the physical properties of the liquid? High vapor pressure or high specific gravity liquids may demand a suction head.
- Have you considered plant and personnel safety under all possible conditions?
- Have you considered maintenance as well as first cost in determining the economics of the system?

If precision pumping of dangerous chemicals is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solution. Write for a general introduction to controlled volume pumping in Bulletin 553-1. Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

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CHEMICAL INSTRUMENTATION SYSTEMS

Controlled Volume Pumps • Quantichem Analyzers • Chemical Feed Systems

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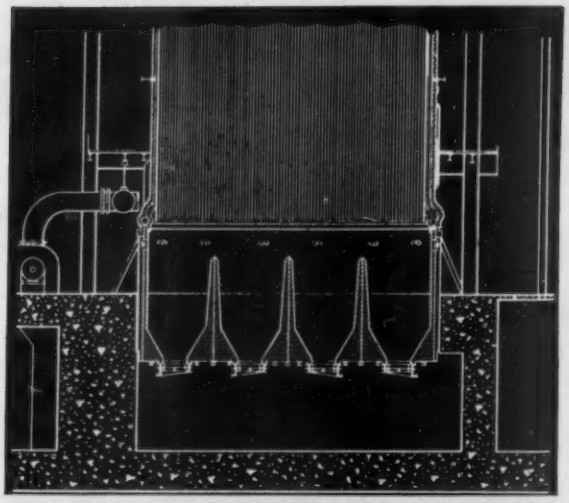
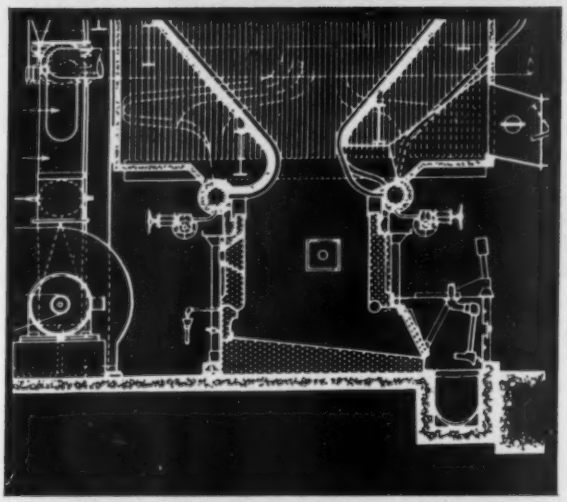
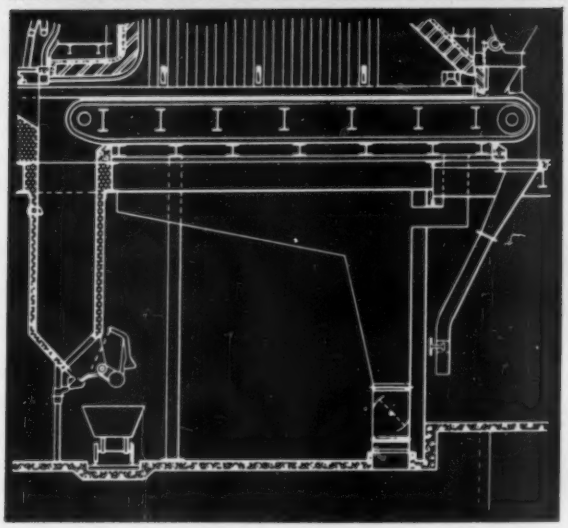


Erosion, due to dry ash sliding down the hopper, is the big problem in this ashpit.



Water jets can cause abrasion of ashpit floor refractories, and water splattered on the walls may cause spalling.



Continuous deposits of ash from a stoker-fired boiler have an abrasive effect on this ashpit lining.

Reduce refractory wear in ashpits with B&W Kaocrete

Relining ashpits is expensive. That's why power engineers specify heavy-duty B&W Kaocrete-D. On job after job, in all types of ashpits, this refractory castable has withstood the heavy abrasive and erosive attacks of sprays, jets, rakes and shovels.

The reason? Specially designed B&W Kaocrete-D has the strength and hardness needed for tough ashpit service. It has unusually high resistance to abrasion, erosion and spalling. It also saves time because it can be cast or gunned in place.

For the facts and figures on Kaocrete-D, as well as Kaocrete-A which is recommended for less severe applications, consult your local B&W Refractories Engineer.

Send for Bulletin R-40 which gives data on B&W Kaocrete Refractory Castables for lining ashpits.

R608

B&W REFRACTORIES PRODUCTS: B&W Alimul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide B&W Ramming Mixes • B&W Kaowool

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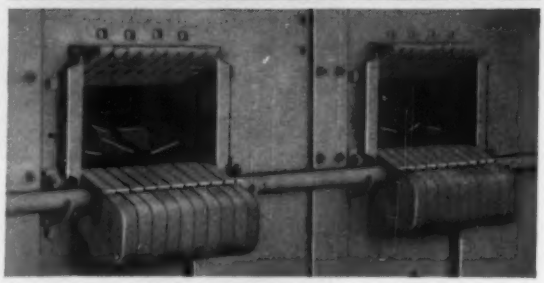
For Fuel Firing Versatility ...Low Cost Maintenance ...High Operating Efficiency

INSTALL

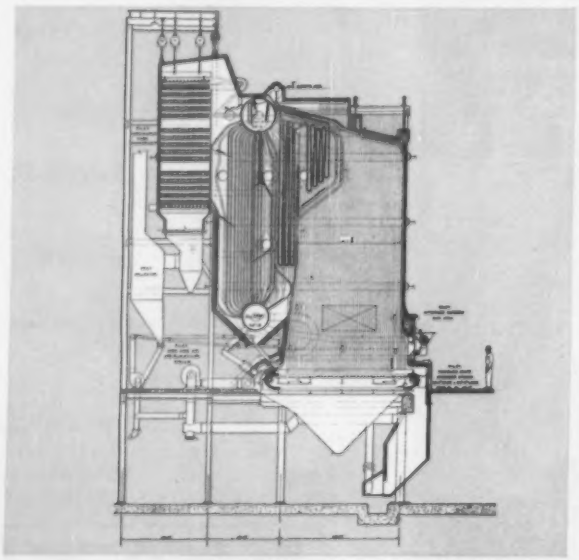
Riley Traveling Grate Spreader Stokers efficiently burn coals having a wide range of coking, caking, and ash fusion characteristics. High working efficiencies are produced with low grade fuels such a sub-bituminous coals, lignite, wood refuse, bagasse, and other cellulose materials.

B. F. Goodrich, Champion Paper and Fibre Co., E. I. Dupont de Nemours, General Electric, Montana-Dakota Utilities, Gaylord Container, Utah-Idaho Sugar, Kennecott Copper, Swift & Co., Bendix Aviation, Armstrong Cork are but a few of many prominent companies that are using Riley Spreader Stokers under Riley Boilers. Such performance-proven installations as these substantiate the superior operating characteristics of Riley Spreader Stokers: uniformity of feed and distribution . . . complete, continuous combustion . . . low carbon loss . . . high day-to-day overall efficiency . . . long-term, low-cost maintenance.



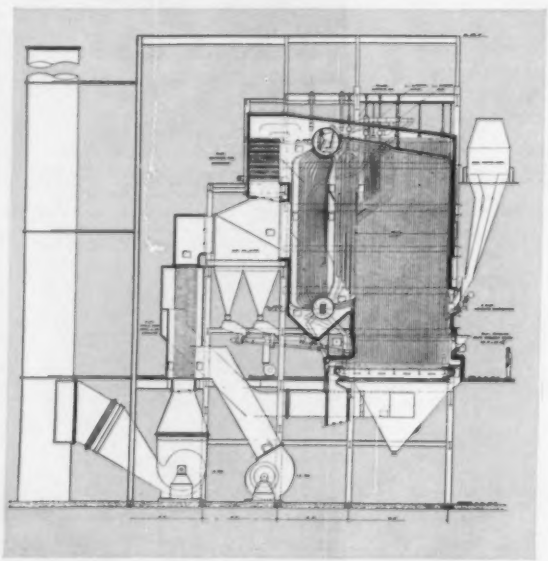
Two Feeder Models

Riley Spreader Stoker Model 'B' Feeders are supplied for capacities up to 200,000 lbs/hr; Model 'D' Feeders for boiler capacities over 200,000 lbs/hr have feeder drum in coal hopper which meters coal regardless of moisture. Adjustable distributor blades give uniform coal distribution.



In Combination With Natural Gas Firing
Deere & Company, Moline, Ill.

20' x 16' Riley Traveling Grate Stokers equipped with Riley Model 'B' Feeders fire two complete Riley Steam Generating Units with pressurized furnaces. Riley Intertube Gas Burners fire natural gas as an auxiliary fuel. Capacity 135,000 lbs/hr, 750F, 650 psig. Efficiency 84.8%.



Simultaneous Bark and Coal Firing
Marathon Southern Corp., Naheola, Alabama

A 26' x 22' Riley Traveling Grate Spreader Stoker, fed by Riley Model 'D' heavy-duty Coal Feeders and Riley Pneumatic Bark Distributors, fires this 300,000 lb/hr Riley Steam Generating Unit with an efficiency of 85%. 975 psig, 825F.

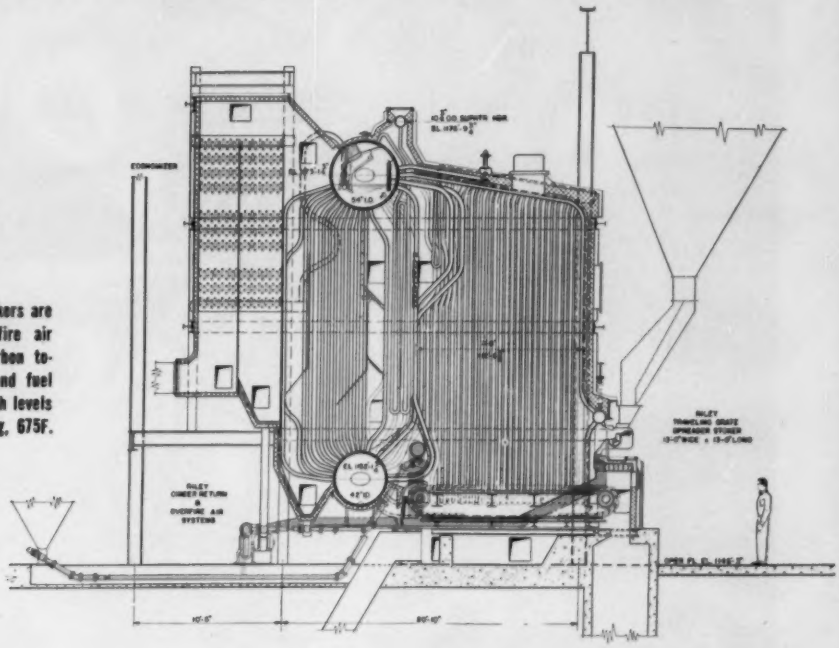
RILEY SPREADER STOKERS

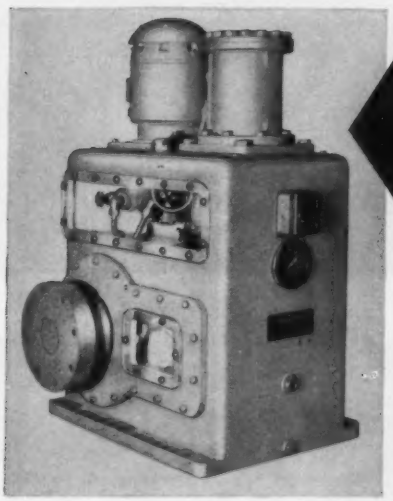
With Either Traveling, Oscillating, Dumping or Stationary Grates

Cinder Return And Overfire Air System

Pennsylvania Railroad, Juniata Shops, Altoona, Pa.

Many Riley Traveling Grate Spreader Stokers are equipped with cinder return and overfire air systems. High recovery of unburned carbon together with intimate blending of air and fuel assures a wide range of operation at high levels of efficiency, 3 — 60,000 lb/hr, 600 psig, 675F.





Smooth, Continuous Operating Hydraulic Drive for Traveling Grates

The self-lubricated Riley Hydraulic Traveling Grate Drive power unit operates quietly and smoothly with uninterrupted continuous automatic or manual speed control from stop to full load. The design does away with sprockets, chains or gears. A pressure gauge describes load conditions at all times.

High Efficiency Grate Surface

Providing high efficiency with low maintenance requirements, the surface of the Riley Traveling Grate Spreader Stoker has small (2" x 6") overlapping grate clips, of special heat-resisting alloy. Nose-over-tail design forces clips to separate when starting return travel, freeing themselves of ashes and clinkers. Tuyeres in the center and at sides of clips give uniform air distribution.

A careful survey of your plant by a qualified consulting engineer could show ways of making substantial savings in power costs.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

Call a Riley Sales Engineer for experienced technical advice covering your requirements for both boiler and fuel burning equipment.

RILEY STOKER CORPORATION, WORCESTER, MASSACHUSETTS

SALES OFFICES: Charlotte, Chicago, Cincinnati, Cleveland, Detroit, Houston, Jacksonville, Kansas City, Los Angeles, Milwaukee, New Orleans, New York, Philadelphia, Pittsburgh, Portland, St. Louis, St. Paul, Salt Lake City, San Francisco, Seattle, Syracuse, Worcester.

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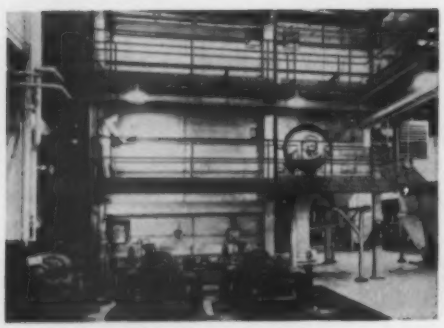
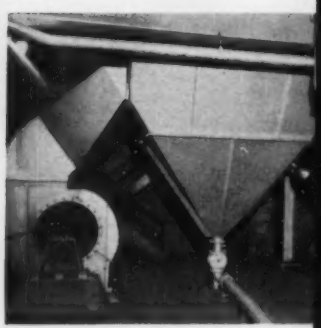


Steam generating plant at Morton, Ill. plant uses two 60,000 lb/hr Wickes boilers, 3 stories high. These are equipped with Hoffman continuous ash-discharge spreader stokers.

Track unloading hopper at York plant. Coal feeds from belt conveyor to bucket conveyor to distributing flight conveyor over storage bunker. Coal handling system by Beaumont Birch.



Ash hopper in Decatur plant. Pneumatic ash removal system by Beaumont Birch Co. connects to vitrified tile ash bin and rotary dustless unloader.

Caterpillar makes tracks for coal

Seven Caterpillar Tractor Co. plants burn coal for low-cost steam generation

When seven plants of a company all burn coal —over 250,000 tons a year—you can be sure there's a *good* reason. At Caterpillar Tractor Co., where steam is used for both process work and heating, coal is burned for low-cost, efficient steam production.

Because of its importance at Caterpillar, steam generation must meet the same standards of efficiency and dependability set up for all phases of plant production. As Caterpillar has expanded from one plant to many, therefore, *each* plant has burned coal.

Coal is lowest cost fuel

Today, *when the annual cost of fuel often equals the original cost of the boilers,* you should know that bituminous coal is the lowest cost fuel in most industrial areas. And modern coal-burning equipment gives you 15% to 50% *more* steam per dollar, while automatic operation trims labor costs and eliminates smoke problems. What's more, tremendous coal reserves and mechanized mining procedures assure you a constantly plentiful supply of coal at stable prices.

Technical advisory service

To help you with fuel problems, the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to address below or send coupon. Ask also for case histories booklet, complete with data sheets. You'll find them informative.

Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—can effect great savings for you with the efficiency and economy of coal.

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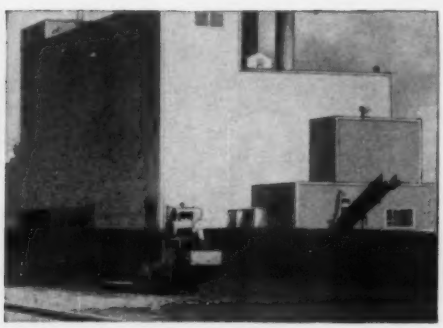
Department PE-06, Southern Building, Washington 5, D. C.

See our listing in *Sweet's*



Exterior view of steam plant at Joliet, Ill. Foreground shows part of outside coal storage area featuring portable car unloader and stacker. Coal is stocked out and reclaimed by Caterpillar bulldozer-equipped crawler tractor.

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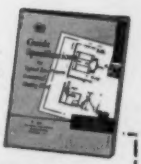

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☐ GS-1 (low-pressure heating plant, screw-type underfeed stoker); ☐ GS-2 (high-pressure heating and/or process plant, ram-type underfeed stoker); ☐ GS-3 (automatic package boiler for heating and process plants). ☐ Case histories on larger plants.

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Company.....

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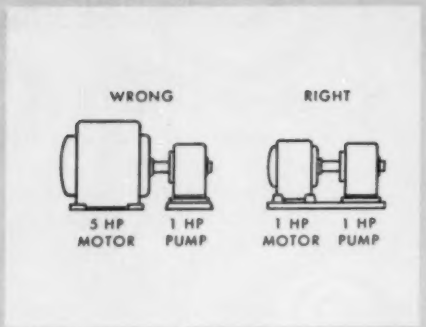
For more data circle 526 on Post Card

Tips on evaluating Electrical

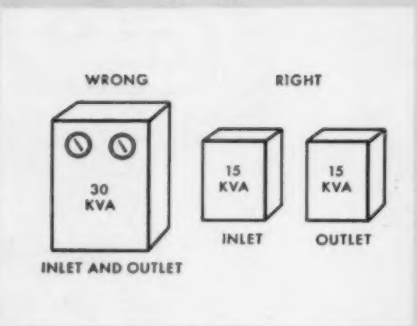
Matched Electrical Sets

You wouldn't use a 5 h.p. motor to run a pump that required only one h.p. Similarly, electrical sets should be *matched* to the requirements of the specific job. Electrical sets should be sized according to gas conditions, dust conditions, and other operating characteristics, and in accord with manufacturers' past experience on similar installations. *Don't be misled by high KVA ratings on the electrical sets.* The precipitator will only absorb a certain amount of power and the sets should be sized accordingly. A large excess of installed power, which will never be used, means inefficient use of the equipment.



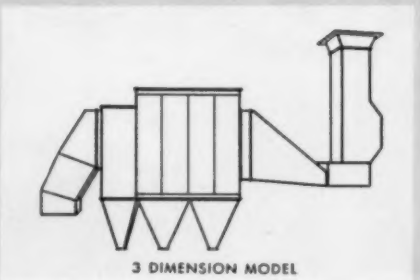
Varied Electrical Conditions

Electrical conditions in a precipitator can vary widely at different parts of the precipitator. For instance, a high voltage, low current condition usually prevails at the inlet where the dust load is high, as compared to a lower voltage higher current condition at the outlet. Consequently, it is good design (and a necessity for high efficiency) to furnish several electrical sections in series, with energization from separate electrical sets so that each section can be adjusted to best suit the conditions.



Gas Distribution

Remember that gas distribution, gas baffling, and provision against hopper sweeping all have a large influence on collection efficiency. The gas flow system should be analyzed as closely as possible, both in the precipitator and in the associated ductwork. If in doubt, have a three-dimensional gas flow study made. Two-dimensional gas flow studies *are not as accurate* and may lead to erroneous conclusions.



RESEARCH

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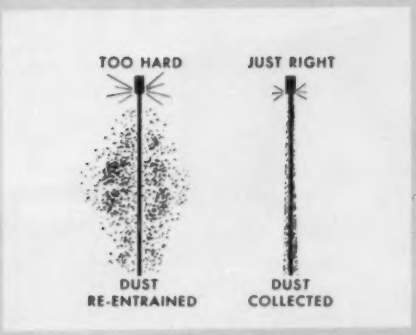
RC 101

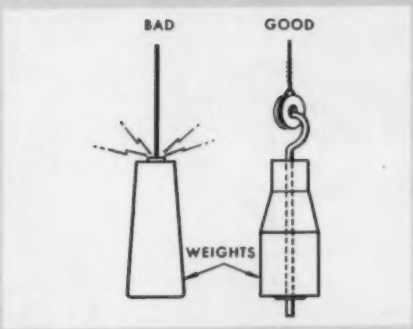
Precipitators

Some helpful hints to aid in selecting a properly designed unit



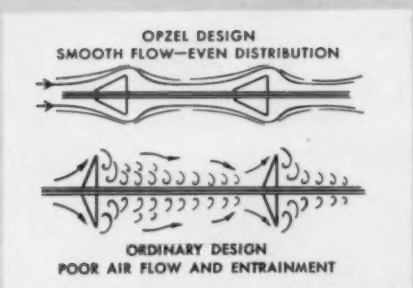
Rapping Intensity

Rappers should have easy means to vary the intensity of the blow to suit variations in operating conditions. A pre-set intensity setting cannot possibly give proper rapping over the normal range of operation. If too soft, build-up will occur which will disturb electrical conditions. If too hard, there will be reentrainment. Means of intensity adjustment are necessary to avoid drop-off of precipitator efficiency as conditions change.



Corona Discharge

It is a relatively easy matter to obtain a corona discharge in an electrostatic precipitator. Many types of discharge electrodes have been used over the past forty years, including ribbons, squares, twisted squares, star shaped sections, coiled wires, wires with prongs and projections, most of which give entirely adequate corona conditions. Final choice then gets down to mechanical factors such as strength of wire, method of support to avoid stress points, and ease of handling. There are many claims made for various types of wires but after investigating and testing hundreds of different kinds, we find a straight round wire about .1" diameter to be best.

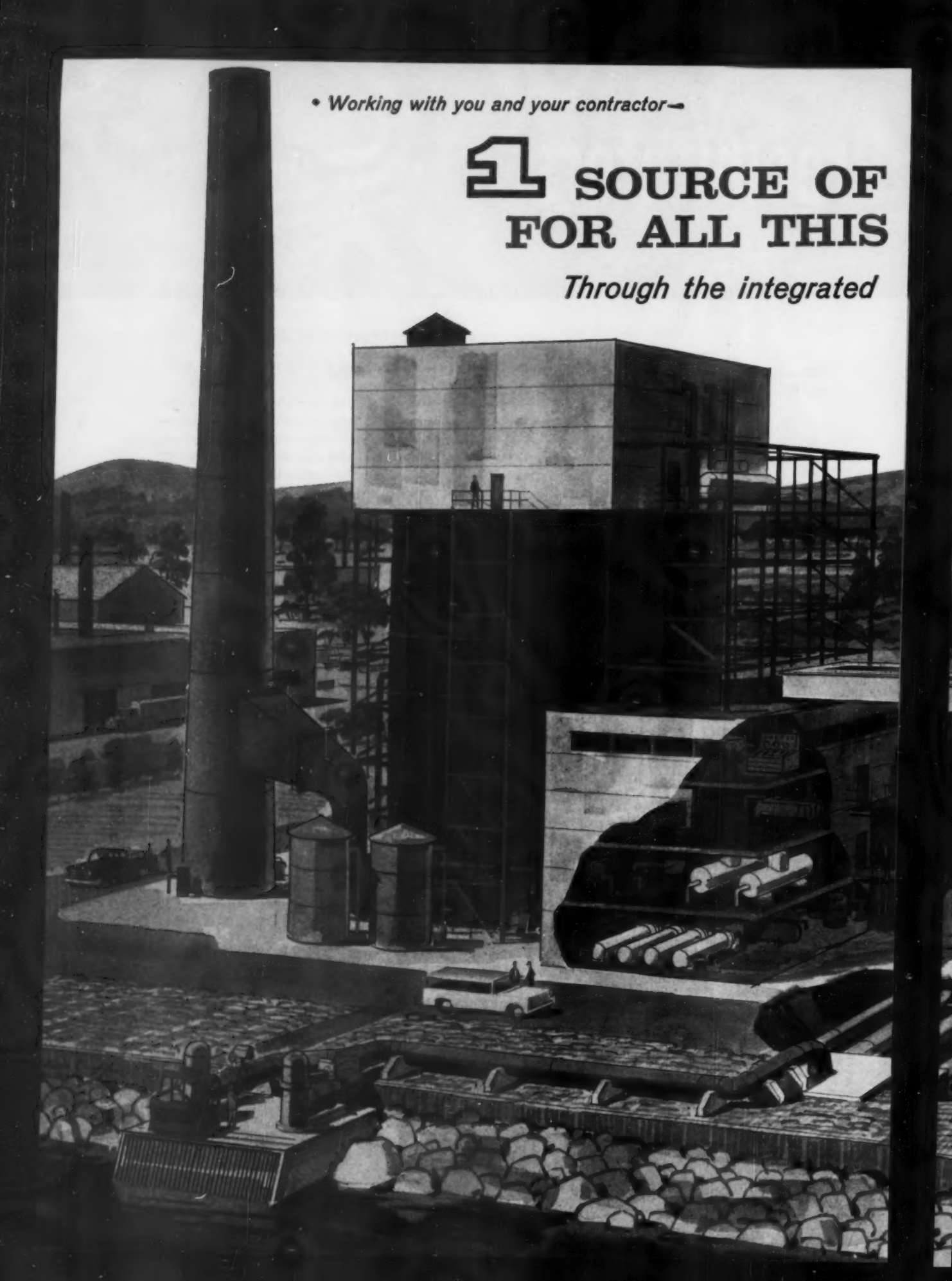


Baffle Design

Careful attention to the design of baffles on the collecting plates is most important. Small amounts of reentrainment mean tremendous differences in over-all collection efficiencies. It is seen that the "quality" of the collecting surface is far more important than quantity — quantity (sq. ft. of surface or treatment time) in itself is not a criterion of performance.

-COTTRELL

Representatives in all major cities of U.S. and Canada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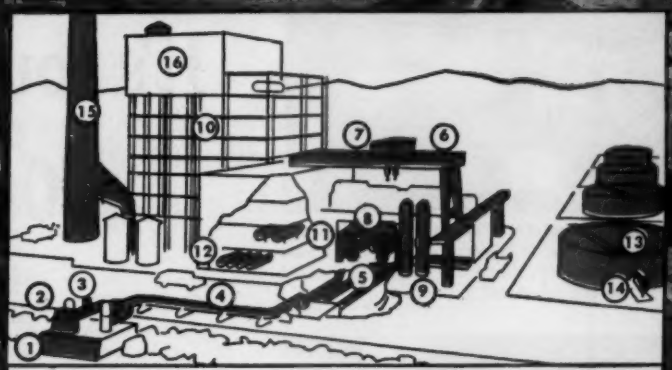

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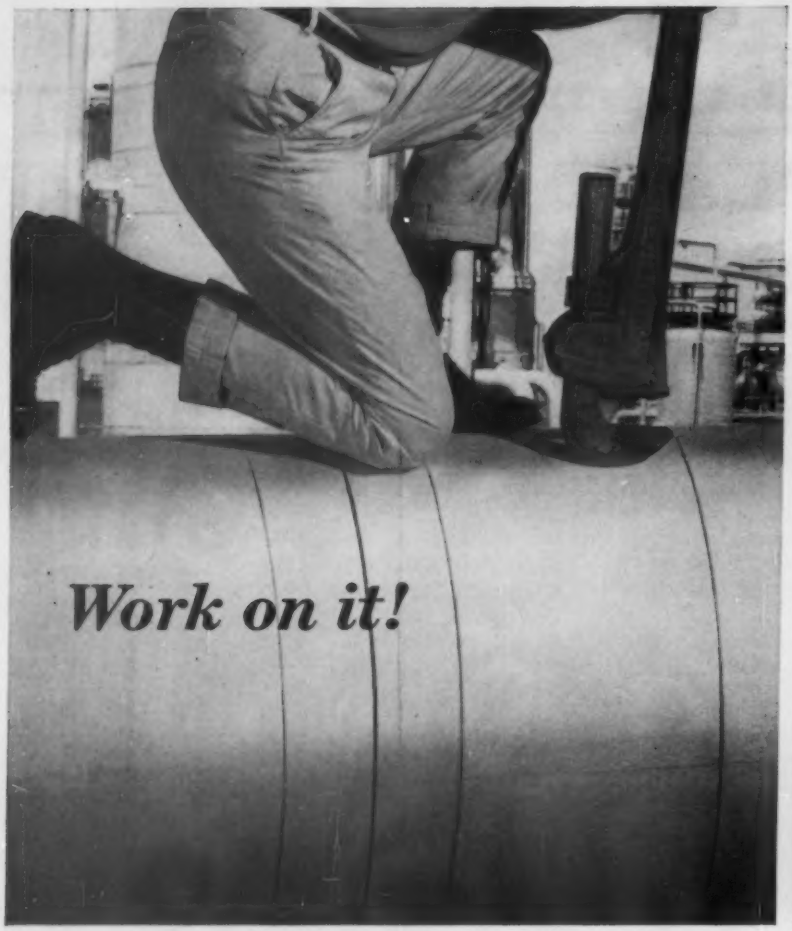

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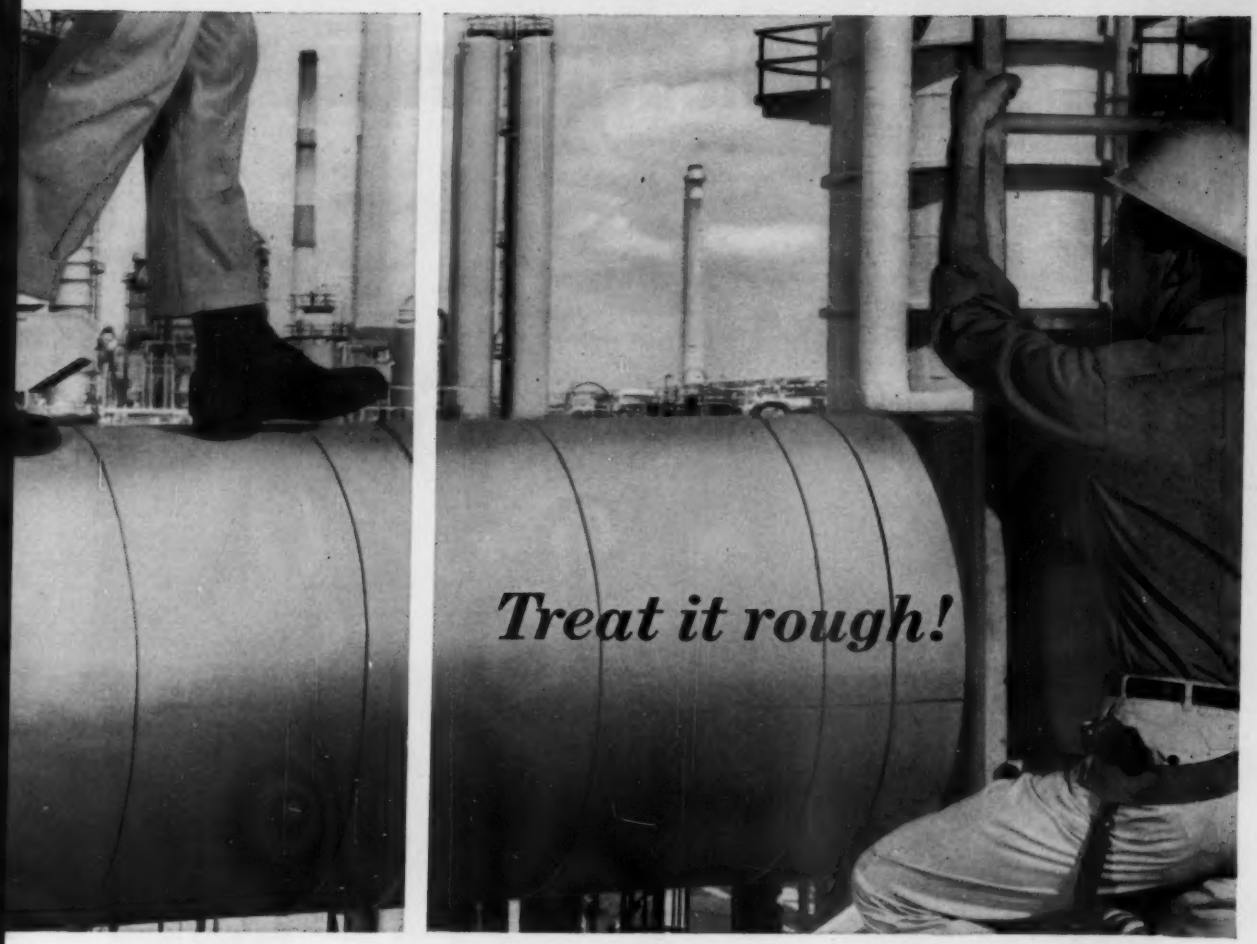

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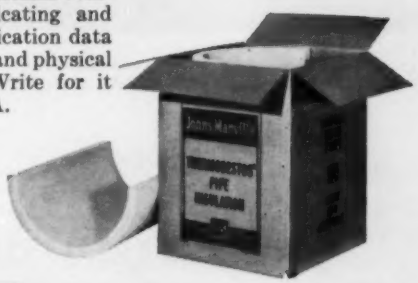

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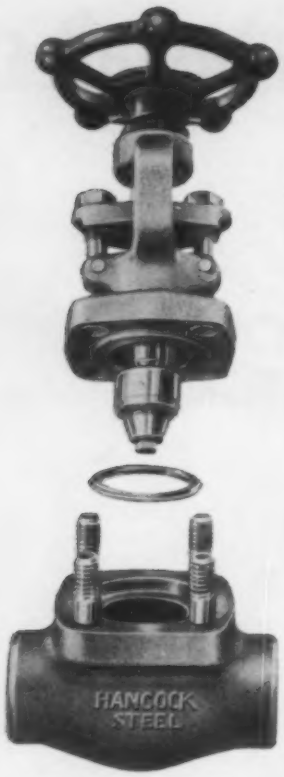

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ATOMICS

A section of POWER ENGINEERING covering current and forthcoming developments in the field of Nuclear Power throughout the world

ANDREW W. KRAMER
Editor

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This editorial, opposite this contents, is merely an introduction to the following article by Mr. Linde of C Stellarator Associates at Princeton. It gives away some of the fascinating data the author presents in his article but only enough to whet the reader's appetite.

Thermonuclear Fusion Research For Power
By Leonard J. Linde 52
In this article the author describes the principles involved in thermonuclear reactions and then outlines the possible lines of attack in solving the difficult problem of bringing about a controlled fusion reaction that will deliver useful power. Finally, there is a most interesting description of the C Stellarator now under construction at Princeton University

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Nuclear Energy For Process and Space Heat in the United States
By Paul L. Geiringer and Morton J. Goodfriend . . . 56
During the past year the authors conducted an elaborate study on the prospects for the use of nuclear energy in heating applications in the U. S. This has been published in the form of an almost 300-page report by the Atomic Energy Commission for which the authors made the study. This article presents the principal conclusions resulting from this study.

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C STELLARATOR—FABULOUS CONTRAPTION

FEW ASPECTS of nuclear science have been of more intriguing interest during recent years than the possibility of developing a controlled thermonuclear reaction that will deliver useful power. As explained in a number of articles which we have published in ATOMICS and in Power Engineering during the last three or four years, the fusion reaction, that is the formation of heavier atoms by combining light elements, has been known for a long time. Such reactions were brought about by bombardment with high-speed particles (alpha particles and protons) as early as 1919. It was not until after the discovery of nuclear fission in 1939, however, that scientists began to think of initiating fusion reactions by thermal methods, namely, thermonuclear reactions for possible use in atomic bombs. Unfortunately, these thoughts led to success in that direction. The hydrogen bomb promoted thermonuclear reactions with a vengeance. The amount of work that has been done in this field is impressive, but practical results have been confined entirely to the weapons area. So far, little has been accomplished that might contribute to our daily lives.

Now, however, a great amount of work is being done in many countries of the world in an effort to bring about a controlled thermonuclear reaction that will deliver useful power. These various research projects are discussed briefly in the article on the following pages by Mr. Linde which is based on a paper he presented recently at the American Power Conference. The primary object of Mr. Linde's article, however, is to describe the thermonuclear project he, himself, is associated with—the construction of the C Stellarator at Princeton University.

Electrical engineers, in particular, will find the description of this astonishing machine almost unbelievable. Peak currents of 700,000 amperes, current densities of more than 30,000 amperes per square inch of copper. Copper bus, 9 square inches in cross section over a mile long, twelve direct-current generators with a combined continuous rating of 48,000 kw—at 600 volts! Actually, the maximum peak rating of these machines is 200,000 kw at 750 volts by virtue of the effect of 20-foot flywheels. Magnetic forces of—but it is unfair to steal Mr. Linde's thunder; it will be much more interesting to read the article yourself. Just remember, this C Stellarator is just an intermediate model; a much larger and more costly one is in the offing.

Maybe after reading about this fabulous contraption you will have the opinion of the farmer who first saw a giraffe—"There ain't no such animal."

Andrew W. Kramer

Thermonuclear Fusion Research For Power*

By LEONARD J. LINDE

Manager, C Stellarator Associates
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

THE PRACTICAL PROBLEMS involved in establishing a controlled thermonuclear reaction from which useful power can be derived is one of extreme difficulty, yet the basic principles are comparatively simple and easy to understand. These principles have been covered in many articles in POWER ENGINEERING and ATOMICS and only a brief review of them will be given here.

Hydrogen is the simplest element. It comprises a single proton forming the nucleus with a negatively charged electron revolving around it. The negative charge on the electron exactly neutralizes the positive charge on the proton so the atom as a whole is neutral. Another type of hydrogen (heavy hydrogen) known as deuterium, has as its nucleus a proton and a neutron but still has only a single electron in the orbit around it. At high temperatures the electrons can be diverted from their orbits so that they wander away. This is ionization. The nuclei are then left with strong positive charges that repel the nuclei from one another. In order to force these positively charged nuclei together — to fuse them into a new and larger mass — they must be driven into collision at high velocity.

The velocity of randomized nuclear particle travel is a function of temperature. The temperature required to fuse two deuterium nuclei together is in excess of ten million degrees. This is termed kinetic temperature, and is measured in electron volts. One electron-volt is equal to 1.16×10^4 degrees Kelvin. As the deuterium nuclei fuse, the two protons and one neutron may form a new nucleus, recognized as Helium-3. The free neutron carries with it excess energy that is available as atomic energy. Figure 1 explains the reaction. Figure 2 pictures the energy available for a complete and controlled fusion reaction. There is an equal chance that tritium (hydrogen-3) plus a free proton will result. Thus, has been established a requirement for extreme nuclei velocity a temperature of at least ten million degrees before the fusion reactions of deuterium can be established. This is the essential condition of a fusion reaction.

At these temperatures, of course, no gas can be confined within material walls. Either the walls would vaporize, or they would cool and quench the reaction. The latter is the more serious problem.

As indicated previously, the deuterium atoms are stripped of their electrons — ionized — at a relatively low temperature. Ionized gas is a plasma and can be likened to an electric arc, or the glow discharge in a neon lamp. This ionized gas or plasma is made up of the positively charged nuclei of heavy hydrogen and an equal number of negatively charged electrons. Thus, it is influenced by a magnetic field. To maintain a fusion reaction, the kinetic energy of the nuclei must correspond to temperatures in excess of 100 million degrees. To be self-sustaining, the energy released by fusion reaction must exceed all losses. The fact that the plasma is influenced by magnetic fields makes it possible to control and confine it in properly proportioned magnetic fields arranged to form a *magnetic bottle*. Thus, the need for confinement by a material vessel can be forgotten; efforts can be directed to properly proportioning a magnetic field to form the bottle.

The requirements for initiating and controlling fusion for power can be summarized briefly as follows: (1) Fusion reactions of deuterium (the most promising fuel) can be initiated at temperatures in excess of 10 million degrees. (2) The heated gas must be confined in a non-material container — possibly a carefully controlled magnetic field — and reach a temperature in excess of 100 million degrees. (3) Reactions can take place in a clean environment — within a vacuum. (4) Gases must be at extreme purity. (5) The reaction must be self-sustaining.

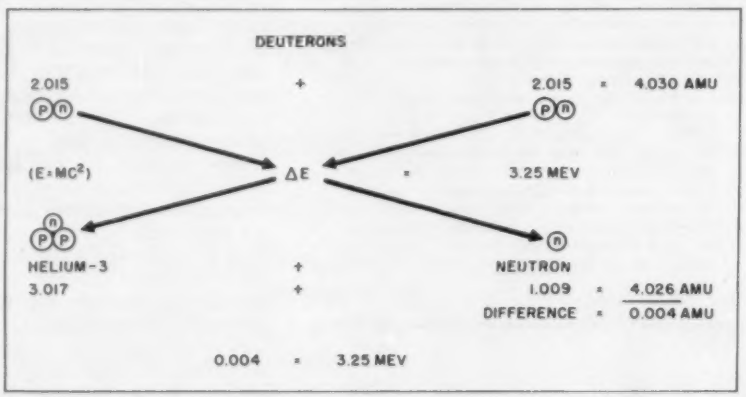


Fig. 1 Typical deuterium plus deuterium reaction resulting in an isotope of helium plus a neutron and excess energy. This is one of several fusion reactions possible.

Research Programs

The research program on fusion is an international task supported by many of the governments of the world. It is an exciting and challenging subject for the physicist, the

*A paper presented at the American Power Conference, Chicago, Ill., March 31–April 2, 1959.

ATOMICS

mathematician and the engineer. Unfortunately, much of its experimental program requires complex and costly laboratory equipment so that many of the major tasks require large expenditures in time and equipment. The individual inventor in his basement workshop, or the physicist in his one-man laboratory, is practically helpless in this field. Private industry plays a part, and an important part, in this research, and several such research programs are active, but the big effort comes from government sponsorship.

The Atomic Energy Commission, in its Division of Research, is organized to sponsor and coördinate this research in controlled fusion. Since 1951, the AEC has supported several laboratories in research programs directed to establishing and controlling thermonuclear reactions for power. This program, "Project Sherwood," was recently unwrapped from its security bindings and displayed its activities and accomplishments to the world's scientists and engineers at Geneva, Switzerland. Other governments followed suit. The conference disclosed the magnitude of the effort and of the task ahead. No startling achievements were recognized. Of all countries it was apparent that the United States' effort was the largest and most broad. The United Kingdom and Russia were next and in that order, and no exciting and new ideas were revealed.

"Project Sherwood," as sponsored by the Atomic Energy Commission, is an active program in several areas of the United States. At Los Alamos, Dr. James Tuck continues theoretical and experimental work toward an understanding of plasma physics. Confinement and heating of the ionized gas or plasma by various geometries of magnetic confinement and compression are the basic studies of this laboratory. The Radiation Laboratory of the University of California at Berkeley and at Livermore continues its important research programs concerning high energy physics. Here, three basic methods for controlling and heating plasma are being carefully explored.

At Berkeley, Dr. R. F. Post has several large straight cylindrical machines using an axial magnetic confining field where the two ends are stopped off with "magnetic mirrors." The difficulties of making the magnetic mirror leakproof continue to be one of the many challenging problems to this approach. S. Colgate, using versions of the pinch effect, includes shock wave heating in his research activities. N. C. Christofilos has been authorized to advance his design studies of the "Astron" concept where a cylindrical sheet of high energy electrons are to confine and heat the plasma. Work to date attempts to establish the stability characteristics of the electron layer itself.

At the Oak Ridge Laboratories, Dr. Shipley and his associates are using an intense carbon arc to cause a high energy molecular deuterium beam to dissociate. The resulting deuterons are then trapped in a magnetic mirror confining field with an inherently high kinetic energy. It is hoped that a sudden increase in the magnetic field will then sustain thermonuclear temperatures from fusion reactions.

Aside from a number of less elaborate programs at the Naval Research Laboratories, at New York University, at MIT and other colleges, one of the most complete programs is the "Stellarator Program — Project Matterhorn" at Princeton University. Dr. Lyman Spitzer, Jr., Professor of Astronomy at the University, is an astrophysicist with a reputation for his original work in "Magnetohydrodynamics," the effect of magnetic fields on the ionized gases of interstellar space.

Spitzer was intrigued with the information, announced by Argentina's Dictator Peron, that a German scientist, Dr. R. Richter, had promised him power from thermonuclear reactions. Spitzer studied this problem while on a skiing trip and worked out an original approach in which the plasma might be confined in an endless tube by means of an externally imposed magnetic field. Elementary theory, however, will show that if a simple torus were to be used as the endless tube, the density of the magnetic field near the "hole of the doughnut" would be greater than at the external circumference. He recognized that this would force the plasma to drift toward the walls. Spitzer reasoned that if the endless tube were twisted into a figure eight, then, because all circumferential distances were equal, local inequalities in the magnetic field densities around the tube would be cancelled out and the plasma might be stabilized. See Figure 3. After circulating a report of these ideas to the Atomic Energy Commission, Spitzer was authorized, on July 1, 1951, to investigate his "stellarator" concept in greater detail. The work was done at the Project Matterhorn facilities at Princeton. During 1952, a "Model A" experimental stellarator was built (in an abandoned rabbit hutch) and experimental results were encouraging. Since that time several other "Model B" machines have been built to study associated phenomena of this stellarator approach. All of these stellarators were of modest size, using a 2-in. vacuum tube about 10 ft in total length.

In the fall of 1954, Princeton started the preliminary design of a larger stellarator that would be large enough and have sufficient field strength to confine the plasma while it was heated to fusion reaction temperatures of more than 100,000,000 K. This machine was to have a pulsed magnetic field in excess of 50,000 gauss with a vacuum vessel 10 in. in diameter, about 45 ft in circumferential length. The plasma was to be heated by radio frequency induction. During this period, however, the entire Sherwood Program was disturbed by theoretical studies that indicated inherent instabilities of the plasma that appeared beyond control. In June, 1955, the design of Model C was deferred. Princeton entered into a period of intensive theoretical and experimental work on its several smaller stellarators.

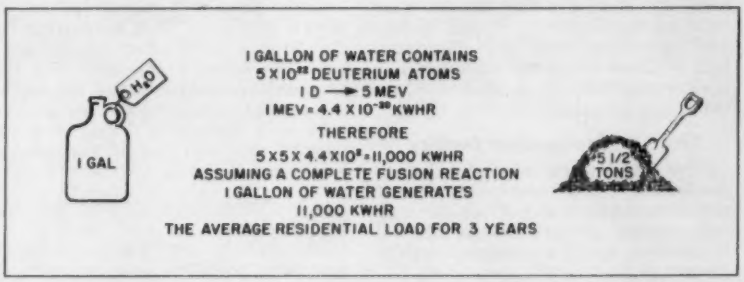

1 GALLON OF WATER CONTAINS
5 X 10²² DEUTERIUM ATOMS
1 D ⟶ 5 MEV
1 MEV = 4.4 X 10⁻²⁹ KWHR
THEREFORE
5 X 5 X 4.4 X 10⁻⁷ = 11,000 KWHR
ASSUMING A COMPLETE FUSION REACTION
1 GALLON OF WATER GENERATES
11,000 KWHR
THE AVERAGE RESIDENTIAL LOAD FOR 3 YEARS
1 GAL
H₂O
5 1/2 TONS

Fig. 2 Energy represented by the deuterium in one gallon of water equivalent to that in 5½ tons of coal.

By April of 1957, the Princeton program was sufficiently advanced to again consider the Model C facility. Several large industrial firms were approached and proposals invited for administration, engineering and fabrication of the complete facility. All invitations were accepted and after evaluation of all proposals by a selection board, the Allis-Chalmers Mfg Co and the Radio Corp of America were selected to handle the project.

On September 3, 1957, a group of management and engineering people from Allis-Chalmers and RCA started work in Princeton as "C Stellarator Associates." Contractual relations are somewhat complex but reasonable. Princeton University has a prime contract with the Atomic Energy Commission for the fabrication and operation of this $35,000,000 laboratory. Allis-Chalmers with RCA, in turn, have a contract with Princeton for the management, engineering and fabrication of all equipment making up the facility, together with the responsibility of conceptual design of

the building. It so happens that each company has an almost equal portion of the work. Both companies contribute to staffing C Stellarator Associates, now a Princeton organization of about 60 persons, about 40 being highly qualified experienced engineers.

The AEC elected to handle building design and construction as prime contracts, looking to CSA for design criteria and coördination. Commonwealth Associates of Jackson, Michigan were selected as architect engineers and Turner Construction Co of New York City was recently engaged as general contractors.

An earlier phase of the laboratory was the design of an administration building and a small laboratories building on the site by Walter Kidde, Architect Engineers. The construction of these accessory buildings has been completed by J. Malan Contractors.

The "C" Stellarator Facility

The engineering staff of Project Matterhorn had prepared a rather complete study that defined the original design parameters of the C Stellarator and its accessory equipments.

It has been the responsibility of C Stellarator Associates or CSA to administrate and engineer the design, construction, installation and test of the stellarator and all associated equipment, subject to the approval of the Princeton-Matterhorn staff. Though completely dependent on its parent companies, CSA operates as an independent unit. The administrative staff includes management, business and contract administration, purchasing and accounting groups. Technical direction for all engineering is shared by experienced individuals from Allis-Chalmers and RCA. All special equipment, such as coils, controls, R-F equipment, mechanical structures and vacuum and gas components, are designed by CSA. Complete specifications for more conventional equipments are completed by assigned engineering groups. A competent design and drafting room completes the engineering activities. Supervision and coördination and scheduling of installation, test and preliminary operation of the facility is a responsibility of CSA. This portion of the organization is manned by field service and erection personnel from each of the "parent" companies.

An interesting side light to this operation is its housing. The entire CSA organization has its office space in the "Theobald Smith House," a large mansion that is a part of the James Forrestal Research Center and was originally built by the Rockefeller Foundation to house the director of the original Rockefeller Medical Research Center near Princeton, New Jersey.

The "C" Stellarator

As finally constructed, this stellarator will be a racetrack-shaped, stainless steel vacuum tube 8 in. in diameter with a total length of about 40 ft. Its U bends will be encircled first with a "stabilizing winding" to provide a "magnetic transform" that proposes to stabilize the plasma in the center of the tube. This stabilizing winding is the magnetic equivalent of the figure 8 tube. The winding is actually six groups of conductors twisted about the U bends of the vacuum tube in a helical fashion as shown in Fig. 4. This suggestion by Spitzer is a more effective stabilizer than the figure 8 and simplifies the mechanical construction of the stellarator. The straight section of the tube will include a "magnetic divertor" that will peel off the outside layer of the plasma to remove impurities from the gas. The opposite straight section will include an insulated and enlarged "ceramic bulge" for heating the plasma to its ultimate temperature by radio frequency magnetic pumping and resonance heating. Large confining field coils encircle the stabilizing winding and the tube around the rest of the racetrack. At either end the tube and coils are again encircled with large transformer cores and coils, transformers used for initial heating of the plasma by treating the ionized gas as a short circuited turn and inducing high currents to heat it by its resistance.

The vacuum required in the large vacuum vessel must reach the unusually low pressure of 10^{-10} mm of Hg. Its original pumping capacity is to exceed 150 liters per second. This work on the vacuum system is being done by RCA at its Lancaster Plant. The confining field coils will be pulsed for two seconds, at 40 second intervals, with the 75 million-amp turns required to establish the maximum 50,000 gauss field around the stellarator. The heavy copper bars in the coils will be water cooled, their current density generally exceeding 30,000 amp per sq in. of copper. Average pulse current is 40,000 amp per turn, copper cross section of a turn, averaging $1\frac{1}{2}$ sq in.

The direct current required for these coils will be supplied by large flywheel type motor-generator sets manufactured by Allis-Chalmers. The system will include three 7000-hp induction motors, three 96-ton flywheels and 12 d-c generators with a combined continuous rating of 48,000 kw at 600 v. Maximum peak rating 200,000 kw at 750 v. The power leveling influence of 20-ft. diameter flywheels will hold peak power demands of the three 7000-hp motors to 48,100 kw.

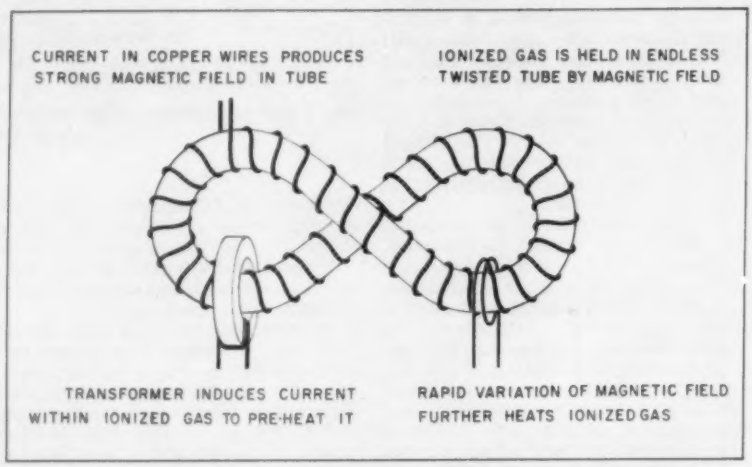

CURRENT IN COPPER WIRES PRODUCES STRONG MAGNETIC FIELD IN TUBE
IONIZED GAS IS HELD IN ENDLESS TWISTED TUBE BY MAGNETIC FIELD
TRANSFORMER INDUCES CURRENT WITHIN IONIZED GAS TO PRE-HEAT IT
RAPID VARIATION OF MAGNETIC FIELD FURTHER HEATS IONIZED GAS

Fig. 3 An early concept of the Stellarator using a twisted tube as a *magnetic transform* to improve stability of the plasma.

One mile of copper bus, 9 sq in. in section, will be required to deliver this power to the confining field coils. High speed circuit breakers, shunting resistors and remote operated disconnects protect the d-c system.

The frame of the stellarator that supports all coils and the vacuum system is to be fabricated from nonmagnetic stainless steel. Magnetic forces are extreme at the axis of the coils, forces between adjacent coils can reach 670,000 lb if any coil is accidentally open-circuited. During normal pulsed operation the compressive force on the machine from end to end will reach 2,200,000 lb. Under these loads the mechanical deflection of coils and frame must not exceed 0.045 in. A weight of 170 tons will make this frame one of the most massive stainless steel structures ever fabricated. All coils

ATOMICS

and framework are being manufactured by the Allis-Chalmers Manufacturing Co.

Radio frequency equipment to heat the plasma must be equally elaborate and powerful. When deuterium gas is injected into the vacuum vessel, it must first be ionized and the nuclei must be stripped of their electrons, so that they will be responsive to electric and magnetic fields. This ionization, or breakdown, is accomplished by imposing a pulse of energy at a breakdown voltage across the ceramic bulge or insulated section of the stellarator tube. This pulse, at from 40 kc to 100 kc, may have a peak power of 400 kw and a duration up to 10 milliseconds. Its power supply will be from large RCA pulse and radio frequency generators.

Once the gas is ionized, the confining field establishes a continuous ring or loop of plasma around and at the center of the stellarator tube. An ohmic heating generator then heats the plasma by inducing high currents in this plasma loop. Six super-power vacuum tubes switch short pulses (from 1 to 5 milliseconds) of power from a capacitor bank with an energy storage of 500,000 joules. Up to 50,000 amp are induced in the plasma through the two large coupling transformers encircling the stellarator tube at the U bends.

When the plasma reaches a temperature of about 1,000,000 K, its conductivity reaches that of a metal conductor and heating by resistance is no longer effective. To reach the higher temperatures required for fusion, two radio frequency systems will then be employed. The nuclei of the plasma will first be agitated by "magnetic pumping" at a frequency of from 30 kc to 200 kc. To accomplish this, a "ringing" circuit will supply up to 100,000 joules of energy to coils encircling the ceramic bulge of the stellarator tube. This energy will result in r-f fields reaching 10,000 gauss at the axis of the bulge. Peak currents of 700,000 amp will be expected in the field coils.

Last stage heating of the plasma will be realized by exciting the plasma at frequencies tuned to match the natural frequency of circular rotation of its nuclei in the confining field. Another r-f generator will supply pulsed power in pulse lengths of from one to nine milliseconds. Because of the greater efficiency of this method of heating, the power output will be in the order of 14 megawatts. The energy storage unit that supplies the plate power to the vacuum tube amplifier will be rated at about 120,000 joules.

The Breakdown and Ohmic Heating systems can supply up to 10 pulses per second. The two radio frequency units may be pulsed at selective rates up to one pulse every two seconds.

The design of the central controls, together with equipment for the processing of data of this research facility, has been a challenge to the engineers of both Allis-Chalmers and RCA. The capital cost and running expenses of a single purpose laboratory of this type demand maximum test or operating time with the effective collection and recording of the maximum amount of useful data. The stellarator will operate under a variety of conditions of field strength, heating energy, pulse time and repetition rate. Automatic timing, to microsecond intervals, is demanded, as well as the automatic gathering and treatment of experimental data. All this must combine with a maximum flexibility of operation. As the research program progresses, the entire facility must be easily adjustable to changes in program and objectives. The conceptual design, as well as the actual design of this elaborate control and data equipment, has been developed by working closely with the experimental physicists and engineers of Matterhorn.

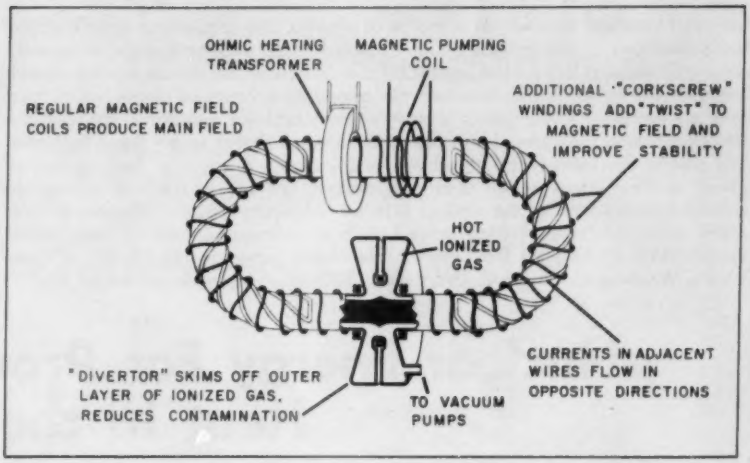

OHMIC HEATING TRANSFORMER
MAGNETIC PUMPING COIL
REGULAR MAGNETIC FIELD COILS PRODUCE MAIN FIELD
ADDITIONAL "CORKSCREW" WINDINGS ADD "TWIST" TO MAGNETIC FIELD AND IMPROVE STABILITY
HOT IONIZED GAS
CURRENTS IN ADJACENT WIRES FLOW IN OPPOSITE DIRECTIONS
"DIVERTOR" SKIMS OFF OUTER LAYER OF IONIZED GAS. REDUCES CONTAMINATION
TO VACUUM PUMPS

Fig. 4 The essential feature of the Model C Stellarator. The corkscrew windings provide the *magnetic transform* instead of the twisted tube.

As a part of this permanent laboratory for fusion research, the following accessory equipment assists in defining the magnitude of the project:

1. Power is purchased at 132 kv, stepped down to both 26 and 2.3 kv through a 30,000/50,000-v transformer. A 5000-mva oil circuit breaker controls and protects this supply.
2. 4000-hp refrigeration compressors supply air conditioning and chilled water for cooling the coils and equipment.
3. Equipment is supplied for demineralizing water to a purity of 1,000,000 ohms/cm³ that will circulate through the stellarator coils and the r-f equipment at a rate of 4000 gal/min.
4. A separate cooling tower will transfer 20,000 kw of heat to the atmosphere.

The C Stellarator Facility is the first new and major facility sponsored by the Atomic Energy Commission for research in fusion for power. It is to be a permanent laboratory directed and operated by Princeton University. Here a succession of stellarators may lead us directly to power from controlled fusion.

This project, Project Matterhorn, is but a part of the larger Project Sherwood of the Atomic Energy Commission. The project faces many scientific problems, many far from resolved, before fusion is controlled for power. Costs and efforts will be great but the return far greater. With power from fusion the oceans of the world could be purified to make the Sahara Desert a garden spot. We hope that the public will be patient.

Scotland's First Nuclear Power Station

SCOTLAND'S FIRST nuclear power station at Chapelcross, near Annan, Dumfriesshire, is now providing electricity to the British Grid System. The first of the four reactors was placed in service on February 25.

This reactor, which went critical last November, had been producing steam for several months but until the turbine generating equipment was completed, the steam was passed into a dump condenser. Now it is being fed to the turbine, and electric power is being produced.

The Chapelcross station, which will have a generating capacity of 184,000 kw, and will, when all four reactors are completed, feed about 140,000 to the national grid, was built by the United Kingdom Atomic Energy Authority as a dual purpose station to provide plutonium as well as electricity. Another nuclear power station is being built by the South of Scotland Electricity Board at Hunterston in Ayrshire for the production of electricity and, when completed, will supply 320,000 kw of power to the national grid.

Work on the Chapelcross station project is ahead of schedule.

The use of nuclear reactors as a source of process and space heat is anticipated to become one of the largest future applications of nuclear energy. A recently compiled study of this subject, made by the authors of this article for the Atomic Energy Commission, has determined the competitive threshold above which heat from conventional boiler plants is more costly than heat generated by reactors. This report also indicates the areas of the United States where fossil fuel costs are above the competitive threshold, and includes a count of the number of plants in these zones where heat requirements are sufficiently high to warrant careful consideration of the savings offered by reactor heating. (For more complete data on this interesting subject, it is recommended that readers obtain Report NYO-2332 from the Office of Technical Services, Department of Commerce, Washington 25, D. C. This almost 300-page report is priced at $2.75.)

Nuclear Energy For Process and Space Heat in the United States

By PAUL L. GEIRINGER AND MORTON J. GOODFRIEND

American Hydrotherm Corp., Long Island City, New York

NUCLEAR ENERGY from the fission of uranium or other fissionable fuel is thermal energy due largely to the kinetic energy of the fission fragments. A nuclear reactor, therefore, is essentially a source of heat. So far, however, nearly all applications of nuclear reactors have been directed towards the generation of electric power, not for the direct use of the thermal energy for heating. The reason for this has been the high cost of reactor systems and associated equipment.

In recent years, however, technological developments have to some extent reduced some of these costs so that it is now possible to determine the areas in which nuclear heating can be justified. In addition to the attraction of offering long-term savings over conventional heating costs, nuclear heating would permit more flexibility in plant location (removing dependence on ease of fuel delivery), greater productive use of available acreage (fuel storage being unnecessary), and elimination of smoke and waste gases. Isotope production might also be possible due to the radiation developed, thus yielding profitable opportunities disassociated with production of heat.

Evaluation of the potential market open to heat reactors is based upon the following considerations:

1. The smallest reactor warranted by 1958 economics is a 20-megawatt unit capable of developing 68,000,000 Btu per hr. However, since it is expected that new reactor design techniques will tend to lower reactor heat costs and that labor and fossil fuels used in conventional boiler operation will be more costly in the near future, the minimum reactor size studied is a 10-megawatt unit (34,000,000 Btu per hr).

2. Load factor of the average process heat plant is about 60 per cent. (This is based upon three-shift operation at maximum output for five days each week, partial operation on Saturday, and complete shut-down on Sunday.) Load factor for space heat plants varies from 20 per cent in the southern states to about 55 per cent in Alaska.

3. Stand-by capacity must be available in case of plant shut-down for emergency repair or periodic maintenance. Conventional boiler plants — of high fuel cost and low investment costs relative to reactor heat plants — are most suitable for the handling of these intermittent requirements.

Reactor Heat Plant

Heat plants used exclusively for satisfaction of process and space heat requirements usually operate at steam temperatures ranging from 200 F to 420 F — far below the level of 600 F which is generally considered to be the minimum temperature of steam used in power production. Plants of this type deliver process heat, combination process heat and power, and space heat. They are used for industrial and district heating systems, in general, where higher pressures and temperatures are required either by certain processes, or by the economic relationship which dictates the use of higher temperature and pressure potentials when the distances over which the heat must be transmitted are large.

Reactors designed for heat generation, specifically, can therefore eliminate various costly features necessary to the high temperature power reactor.

After appraisal of the different reactor designs available, the Boiling Water Reactor — similar to the unit developed in the Argonne Laboratories during 1956 — was selected as most suitable for low-temperature heat generation. The details of the design developed for this project were planned by Paul L. Geiringer, president of American Hydrotherm Corp, and the Technical Staff of the Atomic Energy Division of American-Standard. The heat reactor is rated at 20-megawatts capacity output and is able to provide steam at a maximum temperature of 450 F and a maximum pressure of 400 psi.

The reactor consists of a vertical pressure vessel in which the fuel element core is arranged. The fuel elements — either fully or partially enriched uranium — are set in a regular square pattern and separated by control rods. An alloy of nickel, iron, silicon, and aluminum with small admixtures of copper, lithium, cadmium and boron is the element cladding material for the fully enriched reactor design. Present life expectancy

Table 1—Total Fuel Cost for a 20 MW Reactor at 80% Load Factor

	Cents per million Btu
Fully Enriched Fuel Elements	48.8
Slightly Enriched Fuel Elements, Plutonium Credit of $12 per gram	34.0
Slightly Enriched Fuel Elements, Plutonium Credit of $30 per gram	23.0

is that the reactor core will be usable for at least two or three years before replacement is necessary.

Water, circulated through the core as a moderator and as a coolant, may pick up very small amounts of gamma radiation. This water (vaporized into steam during the cooling process) is sent through a heat exchanger in which it transfers heat to a second system of steam or high temperature water. The secondary system, available for use in process or space heat applications, is therefore secured against any trace of injurious radiation.

The entire reactor and heat exchanger units are enclosed in a containment vessel, designed so that only those lines carrying the steam or high temperature water of the secondary system can leave the vessel. Ample provisions for measuring radiation and for cutting off the various fluid systems shall be installed to permit instantaneous shut-down of the entire reactor plant.

After the initial reactor of this type has been constructed, it is estimated that total investment cost of the 20-megawatt heat reactor would be approximately $1,709,000. Based upon a conservative operating life of 25 years, and an over-all amortization rate of 6.3 per cent per year, it is expected that annual capital charges would be $107,667. Annual cost for operation and maintenance of the plant is calculated to be approximately $149,725.* Thus, fixed charges total $257,392 per year, or about 54 cents per million Btu delivered.

For a 20-megawatt reactor operating at 80 per cent load factor, fuel cost will vary according to degree of enrichment of the fuel elements, and the plutonium credit allowance that is established by the United States Atomic Energy Commission. At the time of this report, estimates of plutonium credit varied from $12 per gram to $30 per gram. Accordingly, total fuel cost would vary from 23 cents per million Btu to 48.8 cents per million Btu, as shown in Table 1.

Determination of Threshold Heat Costs

Conventional boiler plants burning coal, oil, or natural gas, vary in annual cost according to the type of fuel used. The average 20-megawatt coal-fired plant has an investment cost of $730,000, while an equivalent oil or gas fired plant would cost only about $504,000. Similarly, coal-fired plants use more personnel, so that annual labor cost for a 20-mw coal-burning plant is about $84,000 as compared to $55,000 for an oil or gas fired operation. Total annual fixed costs for a 20 thermal megawatt plant are therefore calculated to be about $146,500 for coal-fired installations and approximately $98,200 for oil or gas fired units.

The Threshold Heat Cost estimates indicate that areas where fossil fuel heat costs are 60 cents per million Btu or above show immediate promise for the application of nuclear heating reactors. In many instances, heat costs between 50 and 60 cents per million Btu can presently justify the use of reactor heat.

Due to the possibility that reactor heat plants may become considerably less expensive to build, and reactor operating costs may be reduced as fossil fuel costs increase, areas where fossil-fuel heat now costs between 40 and 50 cents per million Btu may be worthy of consideration in the very near future.

Geographical Analyses of Heat Costs

Delivered fuel cost statistics for coal, No. 6 fuel oil, and natural gas were developed for 118 key cities in the United States (including Alaska). Using a base date of January 1, 1958, to measure the relative costs of these fuels, fuel prices were gathered from a variety of informed sources — chambers of commerce, state governments, fuel suppliers, utility companies, military establishments, and several other groups. In each instance, *delivered* prices — including full transportation costs — were obtained, together with the heat content of the fuel so that conversion of all data into "cents per million Btu" was possible.

From these statistics, the United States was divided into four zones of heating reactor potential:

Zone A — Areas of maximum reactor potential where delivered steam costs totaled between 60 and 65 cents per million Btu or more.

Zone B — Area of moderate reactor potential where delivered steam costs totaled between 50 and 60 cents per million Btu.

Zone C — Area of marginal reactor potential where future economies in reactor costs and increased costs in conventional boiler plant operations may present a more attractive opportunity for nuclear heating. Delivered heat costs totaled between 40 and 50 cents per million Btu.

Zone D — Area of little or no reactor potential where nuclear heating does not appear to be justified. Delivered heat costs are below 40 cents per million Btu.

Process and space heat plants — where present boiler plant capacities exceed 10 megawatts (34,000 lb of steam per hr) — are found to total 4755 installations in the three zones of potential nuclear heating. The breakdown of this figure into industry groups, by geographical zones, is shown in Table 2.

Heat Reactor Potential

The 4755 boiler plant installations located in Zones A, B and C represent those plants presently having heat requirements of 10 mw or more. Mere existence of this heat requirement does not signify that each of these establishments would be receptive to the prospects of using nuclear reactors for heat generation.

Table 2—Estimated No. of Large Heat Users in the U. S.

	Total	Zone A	Zone B	Zone C
Total	4755	669	1201	2885
Process Heat Users—Total	2341	344	619	1378
Pulp, paper and paperboard	534	93	194	247
Chemicals and allied products	517	34	136	347
Food and kindred products	420	18	96	306
Textile mill products	417	120	94	203
Rubber products	188	42	34	112
Plywood and other wood products	102	3	19	80
Leather tanning and finishing	88	27	27	34
Synthetic fibers	31	3	8	20
Hard surfaced floor coverings	27	4	9	14
Tobacco	17	—	2	15
Space Heat Users—Total	2414	325	582	1507
Industrial plants	1303	179	266	858
Military bases	328	50	88	190
Hospitals	279	45	83	151
Colleges and universities	244	25	70	149
District heating plants	80	9	19	52
Prisons and correctional institutions	54	2	12	40
Public housing developments	44	8	22	14
Public buildings	30	1	10	19
Airports	24	4	5	15
Other buildings *	28	2	7	19

* "Other buildings" includes miscellaneous installations reported by state governments which have large heat plants and yet do not fit into any of the above categories. *Not included* in this report are such urban installations as sanitation plants, bus and rail terminals, office buildings, banks, department stores, hotels, laundries, indoor arenas of all types, museums, and other establishments normally located near the center of densely populated areas. While the heating requirements of this latter group are often well above the minimum levels studied, it is felt that the initial applications of nuclear heat should be made in areas where less personal risks may be involved. These urban establishments therefore represent an imposing potential, possibly greater than the sum of all other groups in the space heat category.

* Maintenance is estimated at 2 per cent of total investment cost, i.e., $34,180 per year; labor and overhead total $87,000 annually; liability insurance, as established by the Nuclear Energy Liability Insurance Association, amounts to an annual premium of $20,000; and property insurance (estimated at double the rate for conventionally fueled boiler plants) is $8,545 per year.

New Nuclear Literature

Of the many books published on the subject of atomic energy during the last decade, no book has been of greater real value to the average person interested in this field, technical and non-technical alike, than *Glasstone's Sourcebook on Atomic Energy*. Despite all the other excellent books on various aspects of nuclear science, this Sourcebook has served as a bible for the industry. Written in plain language, with virtually no mathematics, it is as readable as a novel. It presents not only the basic principles of atomic energy but it recounts the history and discusses the various people involved in its early and recent development. The first edition appeared in 1950. Now, published in 1958, we have the second, revised edition.

Early in 1948 the American Textbook Publishers Institute requested the Atomic Energy Commission to prepare a comprehensive sourcebook on atomic energy for the use of textbook authors and editors. The Commission recognized the need for such a volume, and for the preparation of the manuscript obtained the services of Dr. Samuel Glasstone, outstanding scientist and author in chemistry and related fields, who prepared the book at the instance of the Commission.

In his search for material for the Sourcebook, Dr. Glasstone studied the work in the Commission's various laboratories and the files of reports on scientific work. The manuscript was reviewed by a number of scientists associated with the national atomic energy program for technical accuracy and to obtain the benefit of further suggestions.

While originally planned for the specific purpose suggested by the Institute, it was immediately evident that Dr. Glasstone had written a book which was of far broader usefulness and which provided a source of basic atomic energy information for everyone interested in the field.

While the second edition retains practically all of the information contained in the first edition, it contains much new material as a result of the tremendous accomplishments of the last few years. Greatly enlarged and revised, it has been brought completely up to date.

Beginning with the earliest theories of the atom and its structure, the *Sourcebook on Atomic Energy* describes the growth of thought and knowledge in the field, the development of the theories of the phenomenon of radioactivity, and so through the study of isotopes to the construction and operation of cyclotrons, synchrotrons, and nuclear reactors for research and for power. New discoveries in research and development — the identification of hitherto unknown fundamental particles, the transmutation of new elements, advances in the use of isotopes, and vastly improved experimental techniques and equipment are carefully presented. A whole new chapter has been added on nuclear reactors. The presentation is such that the reader with only rudimentary knowledge of science is able to follow the discussion without difficulty.

Clearly written, carefully organized, this new edition of the *Sourcebook on Atomic Energy* provides the essential facts needed for constant reference in every plant, laboratory, school, or library today. This is one book that cannot be recommended too highly. Published by D. Van Nostrand Company, Inc, Princeton, New Jersey, 1958. Price $4.40.

* * *

Another book written for the general reader is a volume recently published by the Philosophical Library, *The Atom and the Energy Revolution*, by Norman Lansdell. This book is based on a study made by Harold Whitehead and Partners, Ltd, a well-known firm of management consultants in England, on the implications of atomic energy. The result was an attempt to present in brief a broad, balanced appreciation of the role of atomic energy in the world of today and tomorrow.

In this book, the author discusses the subject of atomic energy in relation to the other sources of energy and to its general world impact. In industrial organization there is the problem of size, fear of bureaucracy, of the submersion of the individual in contending with the requirements of efficiency. Atomic energy introduces new factors. Economically the world is divided into those countries with highly exploited power resources and those which use little power. Atomic energy may make power equally available to all. What will be the effect on world trade? Conventional energy resources are dwindling in the world in general and in some industrialized countries in particular. Can atomic energy fill the whole gap? World population increase threatens to exceed that of food production. Can atomic energy help, or could it perhaps jeopardize food supplies? Or are we to look to atomic energy to remove the problem by reducing the population? Everywhere beyond the old-established countries we see the exultant growth of nationalism. Can that be reconciled with the world energy situation, with the investment demands of atomic energy, and with the universality of radiological hazards? It is to the discussion of these complex factors in the development of atomic energy that the author of this book presents himself. This book is available from the Philosophical Library, 15 East 40th Street, New York, N. Y. Price $6.00.

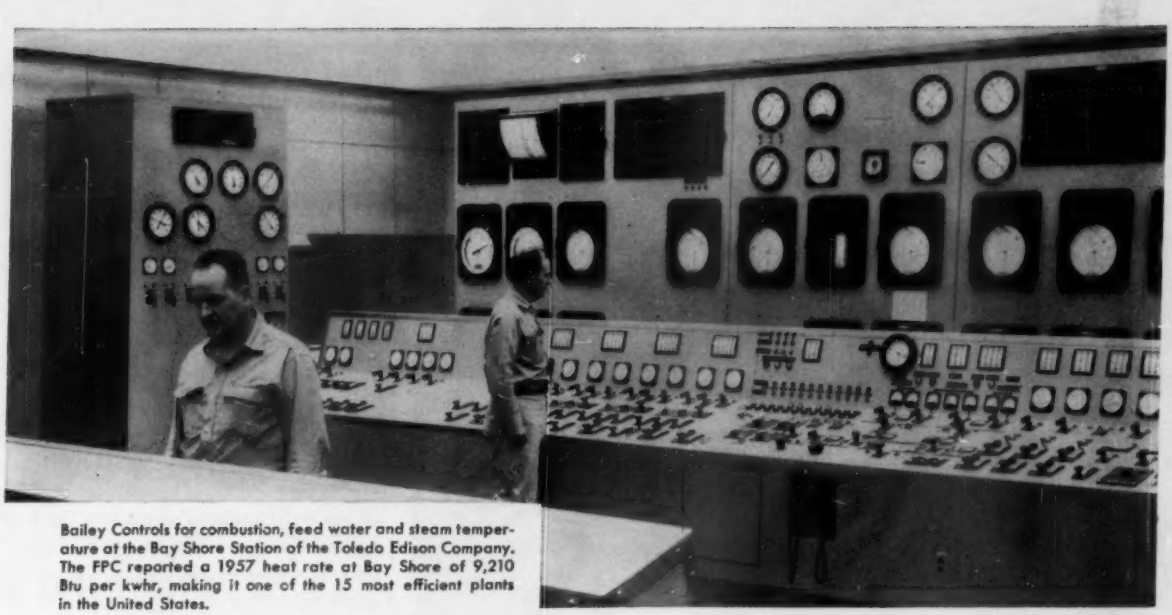
* * *

Law and Administration. The reaction of legislatures and governments to nuclear energy has produced new laws, new administration arrangements and new international institutions throughout the world; these in turn have added another specialty to law and administration. To meet the need for information on this aspect of nuclear energy development, Pergamon Press has just published a new book entitled *Law and Administration, Volumes I and II*, Edited by Herbert S. Marks. These two volumes, combined in a single 994-page volume, present authoritative articles on the legal and administrative aspects of nuclear energy written by specialists. It provides a valuable reference work and source of information for all concerned with or interested in these matters. The book was prepared under the editorship of Herbert Marks, Chairman of the Federal Bar Association Committee on Atomic Energy and former General Counsel to the Atomic Energy Commission, and guided by advisers of international stature.

Volume I comprises eleven chapters, each by a different author. Of the countries where information is available, the United States and the United Kingdom have had the most experience because they have had the most ambitious atomic energy programs. The first four chapters deal with features of the law and its administration in the United States, though each author occasionally refers to experience in other countries as well. The fifth chapter deals comprehensively with the United Kingdom. The next five chapters deal with Euratom and the other important international agencies and arrangements. The final chapter, "Israel and the Atom" is an address by Philip Sporn delivered before the first world assembly of engineers and architects at the Haifa Technion on May 30, 1958.

Volume II compiles the laws and decrees which representative countries have adopted. In all, 25 countries are covered in this section. In the case of most of the countries, brief introductory commentaries preface and help to explain the laws and decrees published. Volume II also presents the treaties, international agreements and related documents establishing the international agencies and arrangements which are described in articles in Volume I. This book is published by Pergamon Press, 122 East 55th Street, New York 22, N. Y. Price $26.50.

ATOMICS



Bailey Controls for combustion, feed water and steam temperature at the Bay Shore Station of the Toledo Edison Company. The FPC reported a 1957 heat rate at Bay Shore of 9,210 Btu per kwhr, making it one of the 15 most efficient plants in the United States.

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* 15 MOST EFFICIENT PLANTS • 1957 Heat Rates Reported by the Federal Power Commission

	Btu/kwhr	Meters	Comb. Control	Feed Water Control	Supht. Control
1. Kanawha River (Appalachian Electric Power Co.)	9,118	B	B	B	B
2. Muskingum River (The Ohio Power Co.)	9,139	B	B	B	B
3. River Rouge (The Detroit Edison Co.)	9,140	—	—	—	—
4. Clifty Creek (Indiana-Kentucky Electric Co.)	9,147	B	B	B	B
5. Tanners Creek (Indiana and Michigan Electric Co.)	9,180	B	B	B	B
6. Kyger Creek (The Ohio Valley Electric Corp.)	9,201	B	—	B	B
7. St. Clair (The Detroit Edison Co.)	9,210	B	B	B	B
8. Bay Shore (The Toledo Edison Co.)	9,210	B	B	B	B
9. G. G. Allen (Duke Power Co.)	9,349	B	B	B	B
10. John Sevier (Tennessee Valley Authority)	9,350	—	—	—	—
11. Phillip Sporn (Central Operating Co.)	9,370	B	B	B	B
12. Milliken (New York State Electric and Gas Co.)	9,371	B	—	B	—
13. Shawville (Pennsylvania Electric Co.)	9,396	B	—	—	B
14. El Segundo (Southern California Edison Co.)	9,467	B	B	B	B
15. Colbert (Tennessee Valley Authority)	9,490	B	B	B	B

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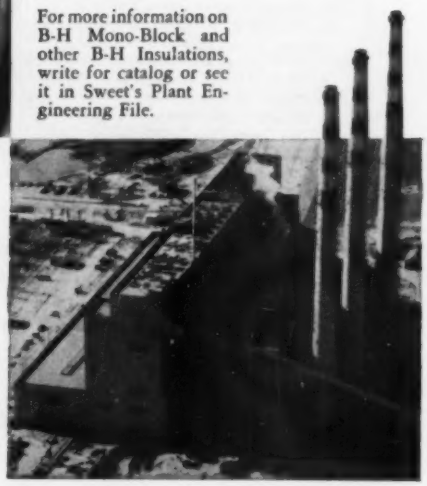

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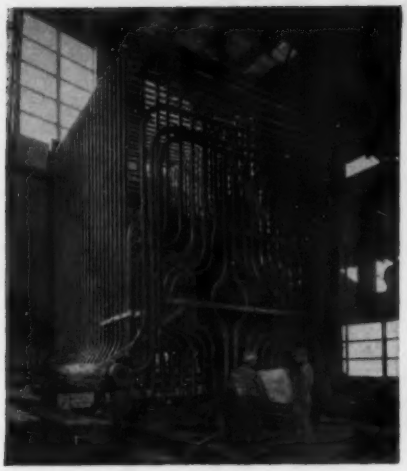

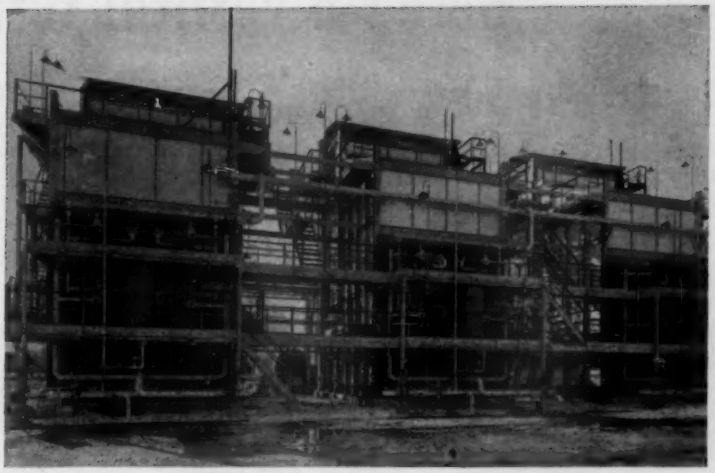

AT LEFT: Installing a 60,000 lbs/hr unit in a brewery

ABOVE: A battery of 125,000 lbs/hr units in a chemical plant

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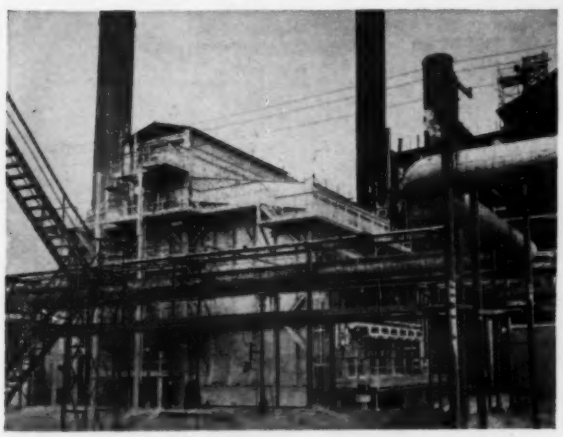

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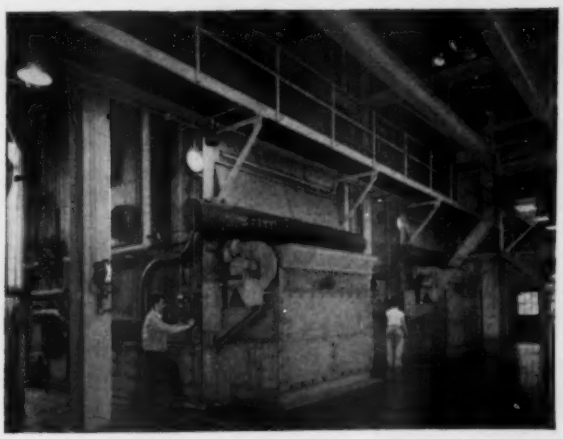

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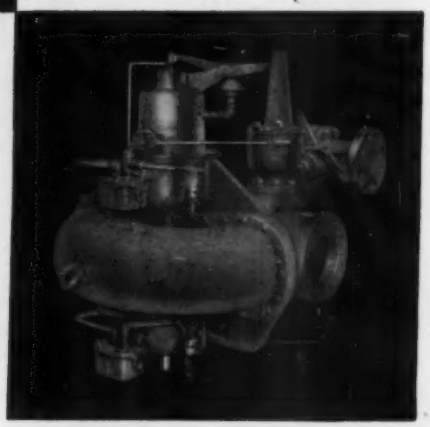

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The City of Memphis Light, Gas and Water Division has just installed three boilers served by six Ljungstrom preheaters. Why Ljungstrom preheaters? One reason is service. Air Preheater engineers don't just wait for a call. They regularly inspect and help maintain Ljungstroms *through the life of each unit.*

What's more, Air Preheater provides rapid *factory* service in an emergency. Here's an example. A customer phoned on a Friday morning for a replacement trunnion—a major integral part of the preheaters. His Ljungstrom was 17 years old, which meant that a new trunnion had to be custom made to match his older-style. He was located 500 miles away. And he needed his boiler back on the line by Sunday.

Air Preheater went to work. Special trucking was arranged. The job was done *and shipped* that same evening. The customer had the trunnion by Saturday morning and the boiler was back on the line by Saturday evening!

Fast response to emergencies and regular inspection of Ljungstrom installations are two of the many advantages Air Preheater provides its customers. Another is expert knowledge of boiler and preheater problems —and how to lick them—gained from over 35 years of experience. Perhaps these reasons explain why 9 out of 10 preheaters sold today are Ljungstroms. For further information write today for free illustrated brochure.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

Ljungstrom rotor being installed for the City of Memphis Light, Gas and Water Division. Six such Ljungstroms—each with 201,400 sq ft of heating surface—will serve three boilers. The boilers will each evaporate 2,000,000 lbs of steam/hr and have a combined nameplate capacity of 750,000 kw. A fourth boiler unit is now under consideration. Burns and Roe, Inc. designed and supervised construction.

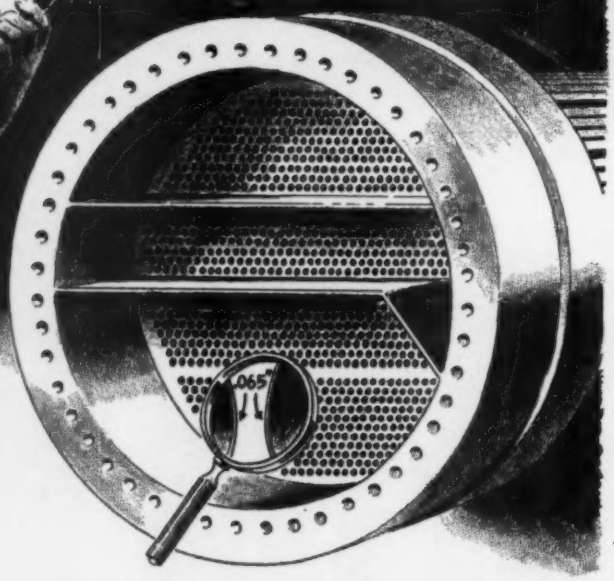
A "stitch-in-time" (Monel) once saved Miss Liberty

IN 1938 MISS LIBERTY WAS DANGEROUSLY CLOSE TO FALLING APART AT THE SEAMS. CORROSIVE ATTACK BY SALT AIR AND INDUSTRIAL FUMES HAD WEAKENED AND LOOSENED RIVETS HOLDING THE STATUE'S HUGE METAL PLATES TOGETHER. BUT SHE WAS SAVED BY 65,000 MONEL* NICKEL-COPPER ALLOY SELF-TAPPING SCREWS WHICH PULLED THE PLATES UP TIGHT. THESE STRONG, CORROSION-RESISTING "STITCHES" STILL LOOK GOOD TODAY—20 YEARS LATER.

Inconel "X" Spring starves "hungry" water...

Withstands corrosive bite of 13,000 tons per hour, at 600°F

13,000 TONS PER HOUR OF HIGH-PURITY WATER AT 500-600°F FLOWS AROUND THE SPRINGS USED TO SUPPORT THE CORE STRUCTURE OF A NUCLEAR POWER REACTOR. TO PREVENT STRESS-CORROSION CRACKING OR EMBRITTLEMENT, THE DESIGNERS CALLED FOR INCONEL "X"* AGE-HARDENABLE NICKEL-CHROMIUM ALLOY. SPRINGS MADE OF THIS ALLOY RESIST CORROSION AND RELAXATION AT HIGH TEMPERATURES—UP TO 1100° IN SOME CASES!



Thin-wall 4300psi heater tubes—5/8" O.D.

THESE ARE THE FACTS ON THE MONEL ALLOY U-TUBES IN FINAL STAGE FEEDWATER HEATERS, NOW AT A NEW OHIO POWER STATION. THEIR 85-FOOT LENGTH MAKES THEM THE LONGEST MONEL ALLOY TUBES EVER MADE. ALTHOUGH THESE TUBES ARE DESIGNED TO WITHSTAND A WATER PRESSURE OF 4300 PSI, THEY'RE ATTACHED TO THE TUBE SHEETS BY ROLLING ONLY! QUITE A TRIBUTE TO STRENGTH AND DUCTILITY OF MONEL ALLOY.

Need help on a metal problem?

THERE'S A GOOD CHANCE THAT INCO'S MECHANICAL ENGINEERING SECTION HAS ALREADY SOLVED A PROBLEM SIMILAR TO YOURS. WHY NOT CONTACT THEM RIGHT AWAY FOR ASSISTANCE? JUST LET US KNOW THE DETAILS.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

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*Registered trademark

INCO NICKEL ALLOYS

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Why Hunter Packing Company uses STANOIL Industrial Oil

Two reasons: (1) STANOIL is a superior oil. (2) Along with STANOIL, Hunter Packing receives experienced lubrication technical service.

A special antioxidant in STANOIL gives the oil resistance to *chemical* change. Deposits are minimized. The oil has a high viscosity index, is resistant to *temperature* change. It lubricates effectively at both high and low temperatures. Due to special refining techniques, STANOIL will not readily emulsify. A special additive minimizes foaming. STANOIL has a low pour point. It flows freely at low temperatures. A rust inhibitor in STANOIL "plates out" on metal surfaces.

W. P. "Sandy" Wehking, the Standard Oil man who calls on Hunter Packing Company, has plenty of experience in technical service work. He's been at it for 17 years. Sandy studied chemistry at Blackburn College. He has also completed the Standard Oil Sales Engineering School.

To get more information about STANOIL Industrial Oil and to obtain technical help on your lubrication problems, call the Standard Oil office near you in any of the 15 Midwest or Rocky Mountain states. Or write, **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

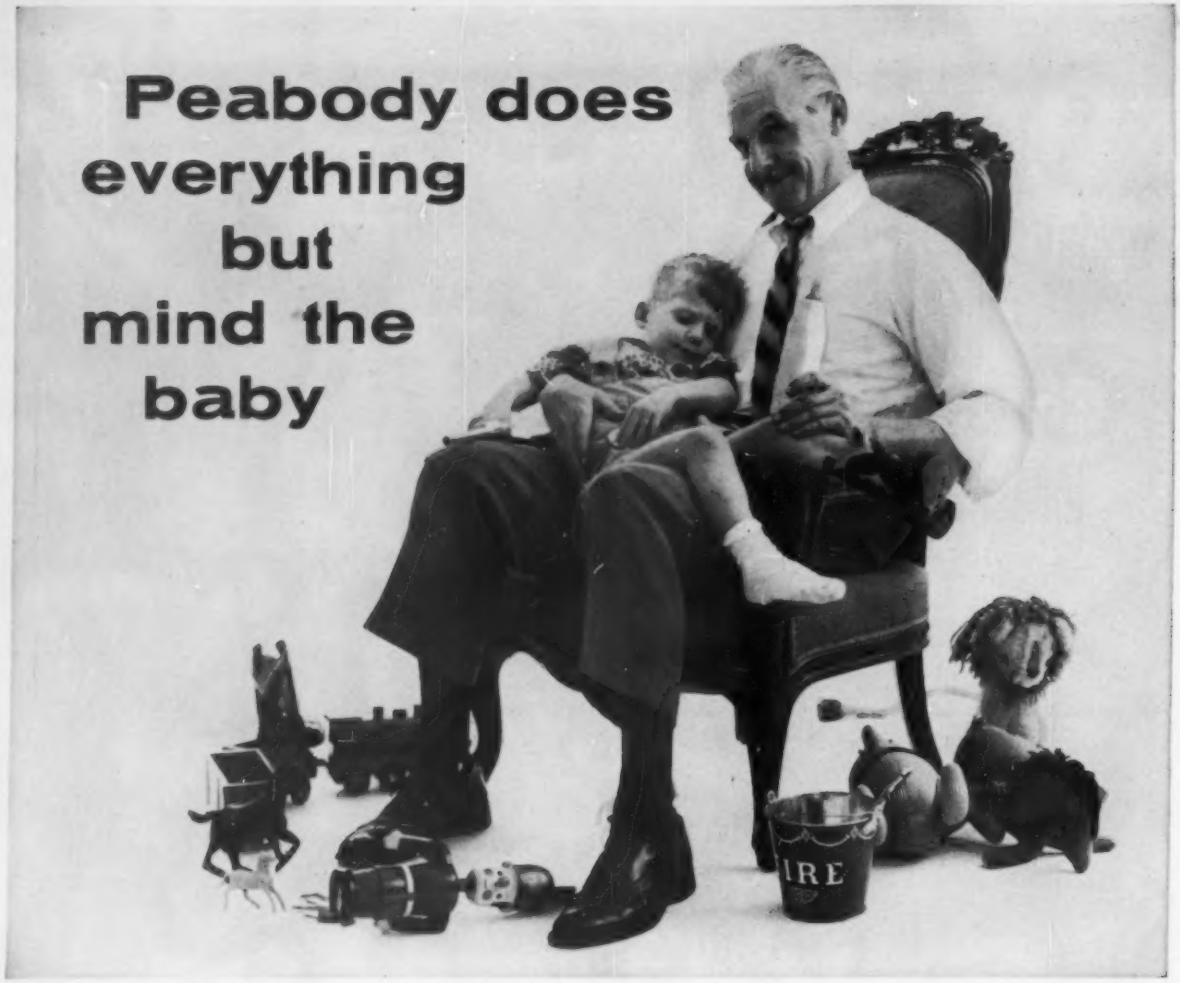
Quick facts about **STANOIL Industrial Oil**

- Antioxidant gives oil resistance to chemical change, minimizes deposits.
- Inhibitor "plates out" on metal surfaces, prevents corrosion.
- Receives special refining to eliminate emulsion problems. Contains additive to minimize foaming.
- High viscosity index. Resists temperature change.

You expect more from STANDARD *and you get it!*

Temperature check. Frank Persson of Hunter Packing Company and Standard Oil lubrication specialist W. P. "Sandy" Wehking inspect one of four compressors in Hunter plant that uses STANOIL Industrial Oil.

Peabody does everything but mind the baby



At Peabody Coal Company You Get More Than Just Coal . . . You Get a Complete Coal Service

From consultation on power problems to the end result, Peabody offers you a complete coal service. Peabody's skilled combustion engineers are available to help you install modern coal-burning equipment, or convert your present equipment to coal. They will determine the *right* coal for your particular needs, and advise you in its most efficient utilization. Your coal will be mined by the latest, most efficient machines . . . then tailor-made in Peabody's ultra-modern processing plants under rigid laboratory control . . . accurately sized, washed and heat-dried. Company-owned railroads, high-capacity loading docks and barge facilities on the nation's inland waterways and major trunk line railways bring the coal to you economically. Yes, Peabody does everything but mind the baby.

This complete coal service is backed by Peabody's two billion tons of proven reserves, to assure you a dependable fuel source for years to come!

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Hall Industrial Water Report

VOLUME 7 JUNE 1959 NUMBER 3

Take the Simpler Things in Life

What could be simpler than water, air, salt? Or more essential to life? Yet they can destroy steel, copper and other common metals and alloys used extensively in industry.

The Hall engineer is trained to recognize corrosion problems in the making and how to combat them. He can help you locate trouble spots and recommend corrective measures before serious damage has been done. That is one of the reasons why the services of Hall engineers are in demand wherever water is used for boilers, cooling, process or general service.

Corrosion Slows Production

When Hall engineer W. E. Pfeiffer visited a new client he was immediately handed a costly problem. When the weather became extremely cold the part of the plant farthest from the boiler house could not be kept comfortably warm, so that the assembly line had to be slowed.

Although repairs to the condensate return system had been minor, Pfeiffer suspected that corrosion products were interfering with heat transfer and proper circulation in the heating system. His suspicion was confirmed when it was shown that condensate was dissolving iron from the piping.

To control further corrosion and to disperse existing corrosion products, Pfeiffer recommended addition of filming amine (Hagafilm®) to the boiler feed water. As the amine distilled out of the boiler with the steam, it loosened corrosion products and laid down a protective film on the metal surfaces wherever steam condensed. With the initial cleanup period over, heating the whole plant is no longer a problem.

Seeing Spots

A Washington hospital reported to Hall engineer W. R. Greenaway that contamination of steam used in autoclaves was spotting stainless steel surgical instruments plated with chromium and nickel. By examining the instruments with a microscope, Greenaway found the problem was indeed serious. The spots were not just stains, they consisted of clusters of tiny pits.

Corrosion of stainless steel pointed to chloride. None was found in condensed steam samples. Only negligible amounts were present in the water and detergent used for washing. As a last resort Greenaway rinsed with distilled water the cloth used to wrap the instruments. A check on the washings proved the cloth to be the source. Condensing steam in the autoclaves extracted enough chloride from the cloth to cause the difficulty.

The job wasn't quite complete. A trip to the laundry was necessary. There it was found that a compound used in the last rinse was high in chloride. Since this has been omitted there has been no further trouble.

Red Carpet Treatment

Stains and poor dyeing caused by iron oxide plagued a Southern carpet factory. Thousands of yards of woolen yarn had to be reworked and sold at substandard prices.

The call went out for a Hall engineer. H. V. Gedney's quick check of the wash water from the scouring lines showed it to be deep red in color. He then surveyed the plant water system from the intake to the trouble points. After clarification the water was satisfactory. But corrosion increased iron content gradually from the filters through the water heater, storage tank and service lines.

With the problem in focus, Gedney had the plant start threshold treatment for corrosion control with Calgon® Composition TG. The red water problem was stopped almost immediately.

Serious water problems can't always be solved in one day. However, the Hall engineer's training and experience enable him to get at the cause of most troubles quickly.

Water is your industry's most important raw material. Use it wisely.

Protective Coatings

Successful application of most coatings to water storage tanks is limited by several factors: water temperature, coating porosity, abrasion and water contamination. But maintaining the continuity of a coating on submerged portions of tanks is extremely important. The tanks are subjected to an oxygen concentration cell type of attack which tends to center corrosion at breaks in the coating. This can cause rapid perforation instead of slow, even corrosion of the total surface.

The organic barriers can be grouped into three large categories: Elastomers include the natural rubber and synthetic products like neoprene. Thermosetting resins cover the alkyd, phenolic and epoxy groupings plus the newer silicones. Thermoplastic materials embrace the vinyl and vinylidene chlorides and polyethylene plus the various coal tar and asphalt base bitumens. Combinations of various resins, resins and metallics, and resins and bitumens are being used extensively.

In many cases, a coating gives unsatisfactory service because it is not applied properly. All corrosion products and other foreign matter must be removed from the surface to be coated. Sandblasting and wire brush cleaning generally work out better than chemical cleaning unless after-rusting can be prevented.

To summarize, protective coatings can frequently be used to protect water tanks if the proper material is used and adequate care is taken in cleaning the metal surfaces and in applying the material.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems, write, wire or call address below.

HALL LABORATORIES
DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

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SERIES 60 FILLS ALL NORMAL STEAM TRAP REQUIREMENTS

If condensate loads are average, pressures between 10 and 400 psi, temperatures under 450° F—then Series 60 are the Yarway Impulse Steam Traps for the job.

These Yarways give you unequalled advantages of *quick heat-up and steady temperatures due to continuous sampling flow, only one moving part, low maintenance, stainless steel construction, small size and light weight, good for all pressures within range, non-freezing, six sizes to choose*—PLUS *low initial cost.*

Specify Yarways on your steam equipment. Buy them from 270 convenient Industrial Distributors. Over 1,250,000 Yarways already sold.

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SERIES 60—normal needs, pressures to 400 psi, 6 sizes. **SERIES 120**—normal needs, pressures to 600 psi, 6 sizes. **SERIES 40**—for extra heavy loads, 5 sizes. **NO. 30**—for extra light loads (½" only). **INTEGRAL STRAINER**—highest pressures and marine use, 6 sizes.

YARWAY | *impulse® steam traps*

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TRACERS

Power Engineering's Monthly Probe of Power Facts

Five-kilowatt thermoelectric generator will be designed and built by Westinghouse for the Navy's Bureau of Ships. Diesel oil or other Navy fuel oil probably will be used as the fuel to be converted directly into electricity in this new thermoelectric power plant. Cool side of the generator will be maintained by cooling with water.

Performance score for aluminum tubes in condensers is high at Wisconsin Electric Power Co, where the material has been under close observation for several years. For greatest economy, aluminum tubes are combined with stainless steel tubes used for top rows and at other areas where erosion or corrosion may be critical. W. A. Pollock describes the Wisconsin company's experience with aluminum, on page 74.

Next important change in gas-turbine technology may well be the incorporation of water or steam injection. Quite startling results are being obtained through the use of this system. For a discussion of arrangements and results, see Jay G. Coutant's article, page 93.

From Westinghouse — a fluorescent lamp that does not require external ballast or starter, and which can be burned in an ordinary light socket. It contains a built-in bi-metal starting switch, and uses an incandescent filament which eliminates the need for the large external inductor ballast. It's not yet available commercially.

Coming ever closer into focus over the horizon of fast-moving developments are nuclear reactors used as a source of process and space heat. Where and when is a reactor a practical consideration for industrial power plant engineering today? For an answer, turn to the article by Paul L. Geiringer and Morton J. Goodfriend in the ATOMICS section, page 56.

Radically new water vehicle has been launched by the U. S. Navy. The craft incorporates airplane-type hydrofoil "wings" and a Lycoming T53 gas turbine engine normally used to power aircraft and helicopters. When a predetermined speed is reached, the lift from the wings becomes great enough to cause the entire boat to rise above the surface of the water, only the hydrofoils remaining in the water.

Low temperature-curing silicone resin has been developed by Union Carbide. It's reported to make possible reduction of as much as 100 C in the temperature required for curing electrical equipment insulated with silicone varnishes.

Hyperbolic (natural-draft) cooling towers have long been in use in Europe, and have many advantages; but cost considerations seem to have held them back in this country. Now J. F. Van Rysselberge presents a realistic way to approach the question of costs of natural draft vs mechanical draft towers. It's on page 96, this issue.

For 20 years, electric rates in Springfield, Illinois, have ranked among the ten lowest in the nation. Average home electric rate of 1.3 cents for all kwh over 250 is the lowest in Illinois. Recently the system established a 1-cent rate for home heating and a 1.08-cent rate for industrial heating and air conditioning.

Take a look behind the scenes and see how the Springfield system operates to provide these low rates, plus contributing some $400,000 a year in cash and free service to the city.

Fig. 1. View of Lakeside Station and water purifying plant at Lake Springfield

This City-Owned Power Department Sets High Record for Efficiency

By **GEORGE M. OLIVER***

HISTORY of the present organization of Springfield's City Water, Light and Power Department dates back about 15 years. At that time, the Department had only two sections — Electric and Water — with a general superintendent, all under the authority of the commissioner of public property.

But this arrangement was proving to be inadequate to cope efficiently with the many difficult problems which confront utility management. Electric load demand was doubling every ten years and the demand for pure water was steadily increasing.

City Water, Light and Power was then reorganized. Still under the commissioner of public property, the Department was split up into nine sections or departments, one of which is the Electric Department (Fig. 3), whose organization and operation are described in detail in this article.

Title of the City Water, Light and Power general superintendent was changed to Utilities Director, and to him report the superintendents of the nine departments. This channeling of lines of responsibility has made for a smoothly functioning operation, with a minimum of disagreement on procedure and planning. The Utilities Director is able to keep the commissioner well informed on all operations, without delay, confusion or difference of opinions.

Turning now to the Electric Department and how we operate.

This department is headed by two superintendents — F. H. Wilcoxon as superintendent of electrical production, and Dean Wisleder as superintendent of transmission and distribution.

Our steam generating plant is located five miles southeast of the city near the Spaulding Dam. These facilities are known as Lakeside Station (Fig. 1) and are operated and maintained by some 55 employees in the various classifications as shown on the organization chart (Fig. 3). We also get assistance in engineering and planning from Burns and McDonnell Engineering Co, consulting firm of Kansas City, Mo.

The Electric Department uses the Federal Power Commission accounting system. This provides adequate information to control operating and maintenance costs and helps shape the planning for improvements.

Operating group for Lakeside Station consists of 26 men or four shifts, working six men per shift, that change every four weeks. The shift schedule shown in Fig. 4 has been used for about 15 years and is preferred over a two-week or a straight shift schedule, which was tried previously. This four-shift plan has the advantage of training men for advancement, since each man works the next higher-paid job when on the swing shift and during vacations.

The men operate the following equipment and auxiliaries: five turbine-generator units rated at 10, 15, 15, 20 and 20 mw; six boilers rated 125,000, 150,000, 150,000, 200,000, 250,000, and 250,000 lb per hr; four city water pumps rated at 12,000,000, 15,000,000, 18,000,000 and 25,000,000 gal per day.

Boilers have automatic combustion and feed water control. The city wa-

Fig. 2. Training and close planning must undergird efficient operation. Here Harold Wilcoxon holds weekly maintenance meeting with (l to r) C. P. Hafel, electrical engineer; Merl O. Chambers, who is maintenance foreman; Charles Marr, civil engineer; and Ross Atkins, assistant plant superintendent

*Formerly Commissioner of Public Property, City Water, Light and Power Dept, Springfield, Ill.

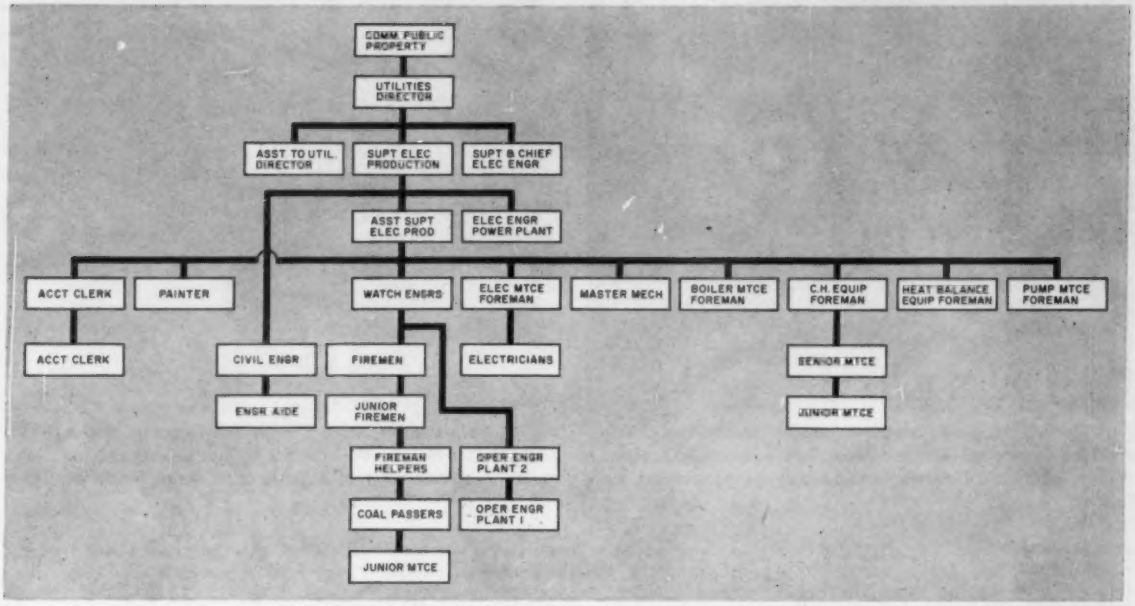

Fig. 3. Organization of the Electric Department. Two-man team—for generation and transmission-distribution—runs it

ter pumps are manually controlled by varying the speed to maintain 50-psig water main pressure at the City Hall. This is recorded at the power plant by telemeter and a variation of five lb plus or minus will sound the alarm. Operators then make the necessary change in pumping.

This equipment is operated or shut down as the load demand requires, with the more efficient units operating most of the time and the least efficient used only for peaking and stand-by purposes.

Operating shift personnel is supervised by the watch engineers. The other five men are two operating engineers, a fireman, assistant fireman and a fireman helper.

Several log sheets are used to record hourly readings, operating data, and maintenance needed. All meters are read and charts changed at night. From the data, daily and monthly production reports and records are made.

Three of the turbines operate at 400 psig, 700 F, and two operate at 675 psig, 875 F. The six boilers are pulverized coal fired and have overhead bunker capacity totaling 1450 tons. The coal is purchased from central Illinois mines within trucking distance. All coal is now delivered by trucks hauling six days a week. Bunkers are filled daily by a conveyor and crushing system where coal is crushed to $\frac{3}{4}$-in. by two crushers at 75- and 100-ton capacities per hour. Some coal, stored during the week near the truck hoppers, is pushed into the hoppers by a bulldozer on Sunday when the trucks are not hauling. All coal is purchased on a cost per million Btu contract containing penalty and bonus clauses. The coal is weighed on the 60-ft platform scale which is owned and operated by the department. The delivered weights are used to eliminate leakage and windage transit losses.

About 30,000 tons of coal are stockpiled near the truck hoppers in case of mine outages due to labor strikes or forced shutdowns. This is stockpiled or taken from storage by the bulldozer or dirt mover. When replacing storage coal it is spread and thoroughly compacted to prevent deterioration and internal combustion. It is only necessary to operate the coal handling equipment during the day shift, since the bunker capacity is adequate to run through the other 16 hours between handling periods.

Maintenance group consists of 15 to 18 men supervised by six foremen under the following categories: master mechanic, boiler maintenance, coal handling equipment, pump maintenance, electrical maintenance and closed heater and piping. These foremen make a weekly inspection of all plant equipment by use of a check-list. These check-lists, together with a list of maintenance items, are used at a maintenance meeting held every Friday to plan the work for the following week.

Work performed is removed from the maintenance lists of each foreman and new items added from the operating log sheets or from the foremen's check-lists. Items affecting op-

REGULAR OPERATORS—SHIFT CHANGE SCHEDULE

	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
12 PM– 8 AM	A	A	A	A	D	D	A	A	A	A	A	D	D	A	A	A	A	A	D	D	A	A	A	A	A	D	D	A
8 AM– 4 PM	D	B	B	B	B	B	D	D	B	B	B	B	B	D	D	B	B	B	B	B	D	D	B	B	B	B	B	D
4 PM–12 PM	C	D	D	C	C	C	C	C	D	D	C	C	C	C	C	D	D	C	C	C	C	C	D	D	C	C	C	C
12 PM– 8 AM	D	D	D	D	B	B	D	D	D	D	D	B	B	D	D	D	D	D	B	B	D	D	D	D	D	B	B	D
8 AM– 4 PM	B	C	C	C	C	C	B	B	C	C	C	C	C	B	B	C	C	C	C	C	B	B	C	C	C	C	C	B
4 PM–12 PM	A	B	B	A	A	A	A	A	B	B	A	A	A	A	A	B	B	A	A	A	A	A	B	B	A	A	A	A
12 PM– 8 AM	B	B	B	B	C	C	B	B	B	B	B	C	C	B	B	B	B	B	C	C	B	B	B	B	B	C	C	B
8 AM– 4 PM	C	A	A	A	A	A	C	C	A	A	A	A	A	C	C	A	A	A	A	A	C	C	A	A	A	A	A	C
4 PM–12 PM	D	C	C	D	D	D	D	D	C	C	D	D	D	D	D	C	C	D	D	D	D	D	C	C	D	D	D	D
12 PM– 8 AM	C	C	C	C	A	A	C	C	C	C	C	A	A	C	C	C	C	C	A	A	C	C	C	C	C	A	A	C
8 AM– 4 PM	A	D	D	D	D	D	A	A	D	D	D	D	D	A	A	D	D	D	D	D	A	A	D	D	D	D	D	A
4 PM–12 PM	B	A	A	B	B	B	B	B	A	A	B	B	B	B	B	A	A	B	B	B	B	B	A	A	B	B	B	B

Relief engineer works three shifts to relieve watch engineer and two operating engineers when they are on swing shift.

Relief boiler room man works three shifts to relieve fireman, junior fireman and fireman helper when they are on swing shift.

Fig. 4. This shift schedule has been used for 15 years, is preferred over a 2-week or a straight shift schedule because it provides for training for advancement

Fig. 5. Well-equipped machine shop for maintenance chores reduces operating costs for Springfield's power department. Master mechanic George Burton metal-sprays a motor shaft

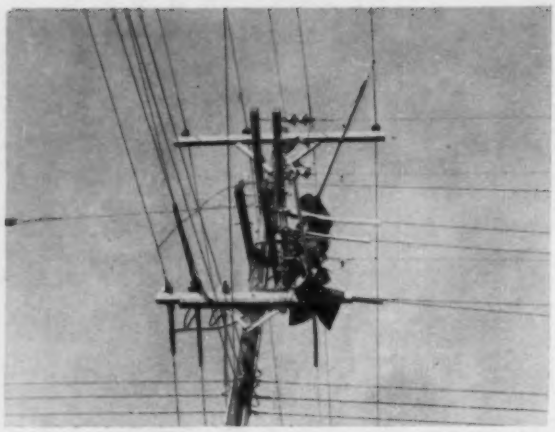

Fig. 6. Power department line crews are converting 4160-v and 2300-v lines to the new 12,500-v lines. Major improvements in transmission and distribution were made in 1957

eration are given priority and arrangements are made to delegate enough men to the foreman to get the work done quickly and efficiently.

The weekly maintenance meeting has improved our preventive maintenance program. By use of the checklist, needed repairs or service are detected and completed before breakdowns occur. Because of more thorough checking of equipment, complete overhauling is now done less frequently. Turbines which were formerly overhauled every three years are now overhauled on a four-year schedule. The boilers are taken out of service for the annual internal inspection as required by state law. At that time all auxiliary boiler equipment is cleaned, inspected and repaired. All maintenance foremen are notified of the boiler outage and proceed with their phase of the work.

We use a Kardex system for listing all major equipment. These cards show nameplate data, parts on hand, overhaul periods, maintenance costs and other important data for planning repairs or replacement of equipment.

Expansion Program

All major construction is done by contract. The planning for this work is done with the commissioner of public property, department heads and engineers, and consulting engineers working together. Specifications for contracts are written and awarded to prequalified low bidders by City Council action.

We are presently engaged in a $7,500,000 plant expansion program at Lakeside Station, which will add a 33-mw turbine generator and a 320,000-lb-per-hour cyclone-fired boiler. They will be operated as a unit and are scheduled for initial operation in June, 1960. Many modern features are incorporated, with emphasis on future long-term planning. A few of these are: air-conditioned centralized control room; improved building ventilation; outside oil storage vaults for quantity purchasing; demineralized boiler feed water; intercom-loud speaker system; pressurized boiler; automatic sequential soot blowers; 30-psig hydrogen cooling; modern annunciator system; and induction brushless exciter.

Controls

Controls for the new boiler, two existing boilers, and space for the next boiler are provided in the new control room. The new turbine-generator controls are provided in this same control room. Our future load growth curve indicates that the next boiler and turbine will be needed about 1965. At that time, our watch engineer or shift supervisor will be moved to the centralized control room which will then contain the controls for the following units and their auxiliaries: boilers — two 250,000 lb/hr; one 320,000 lb/hr; one 430,000 lb/hr; turbine generators — two 20,000 kw, one 33,000 kw, one 44,000 kw.

The three units in plant No. 1 which are now operated from the existing control room will not be changed as they will only be used for peak loads or stand-by service. It is planned to convert substations to automatic switching with supervisory control. The dispatcher will then probably be located at the power plant in the existing control room. It will be the dispatcher's responsibility to control all switching necessary to transmit power from the main bus to the substations and distribution system. It will be the responsibility of the power plant operators to put the power on the bus.

My conviction is that efficient operation can only be attained by providing those charged with the operational aspects of production with the skill, information, and training necessary to do the job efficiently, effectively and safely. These operators and maintenance men must be taught to recognize the dangers and be able to safeguard themselves and equipment against accidents, so that continued productivity is the result. Safety is a by-product of adequate job training, proper supervision and competent job performance. Manpower is the most important asset in any company and should never be wasted.

This philosophy is carried out in the training programs and safety programs which we are encouraging at the present time. The organization for plant operation is set up so that the men are given a chance to move up to the next higher-paid classification during vacations and when on the swing shift. This gives them confidence and encouragement, and advancement and responsibility are accepted without jeopardizing plant operation.

This training program also fits in with the plant expansion, for it has included sessions designed to acquaint the men with the installation, operation, and maintenance of the new equipment. The master mechanic and maintenance foreman will help supervise the erection and installation of new equipment. The men who will operate the new equipment will help blow out lines, start up, adjust and test-run the equipment. As the equipment plans and details are received, they are discussed at the training programs.

When the new equipment is received and erected, the training program will explain the controls and operational procedure as well as repairs and maintenance details.

Transmission and Distribution

Power is transmitted from Lakeside Station by a 23,000-v system and a 69,000-v system.

The 23,000-v system is the older and in its present configuration has a firm capacity of 45,000 kw. Four transmission lines radiate from the generating station toward Springfield. Two of them are tied together

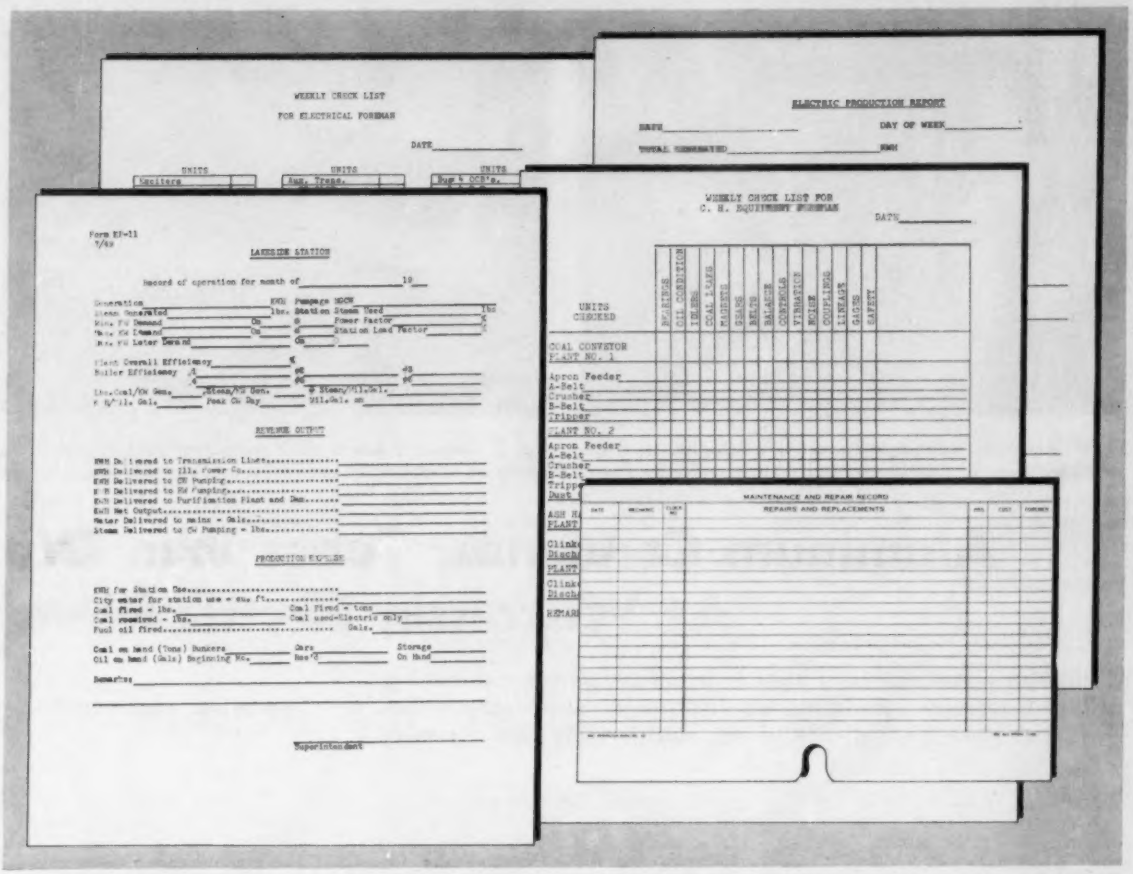

Fig. 7. Lakeside Station's most important record forms are these: weekly maintenance check-lists; monthly report on efficiency of production; daily production report on load and water trends; Kardex system keeps daily record of all equipment data

in the southwest corner of the city; the other two are tied together near the business district, the transmission system at this point representing two rabbit ears with the generating station at the head. A fifth transmission line ties the tips of the ears together.

High-speed modern relays are used but the problem of setting them is quite critical because of the shortness of the lines. There are 15 substations ranging from 1500 to 9000 kva. All of these substations distribute their power either at 2300 or 4160 v. The 69,000-v transmission system was completed in 1957. It is a 25-mile loop sectionalized in three points. There are two substations of 10,000-kva installed capacity and one of 20,000-kva installed capacity. All are designed for further expansion to twice their present capacity. Sites for additional substations are already purchased.

All distribution from the new substations is 12,500 v. The areas served by this new high distribution voltage are the extremes in load density. One of the substations will serve the concentrated load in the downtown area. Other substations on the 69-kv loop, either existing or to be built, serve the band around the city. New growth in the residential areas will be in this band so that new construction can be put in originally at 12,500 v. Expensive conversion from low voltage to high voltage will thereby be held at a minimum because as the city grows outward, the new system will be built originally for the high voltage.

Engineering and construction of the transmission and distribution facilities, with one exception, has been handled by the department's own personnel. The exception is the new 69-kv transmission system and substations, where the man-hours for detailed engineering required the service of a consulting engineer, and the man-hours of construction dictated that the job be installed by a large contractor in order to get it completed in the time necessary.

Operation and maintenance of the transmission and distribution system is performed by the department's personnel, with the exception of tree trimming. An annual contract is arranged with the successful bidder for tree trimming, by which we can draw on as many crews and equipment as are necessary and at the time they are necessary. In this way a reservoir of manpower is on tap when storms occur. For many reasons, tree trimming is more easily handled through a contractor. Men within the organization frown on tree trimming and transfer to other electrical work as soon as the Union bidding procedure provides an opportunity elsewhere. It is difficult for the department to develop men who like tree trimming and are willing to stay with it long enough to understand the peculiarities of this important work.

Whether it is operation, maintenance, or new construction, the amount of work to be let out on contract is determined by economics and sound operating procedures. The department's personnel operates on a full schedule all year around. The men are versatile and entirely familiar with the system and afford a large reservoir of manpower in case of storm or emergency. In general the quality of their work is higher than that done by contractors, and the majority have real pride in their system.

Turnover is low. Happily, the point of balance between contracting forces and department forces is the same for good economics as it is for good operating procedure. **THE END**

— Photo courtesy Allis-Chalmers

Fig. 1. Aluminum tubes being inserted in 105,000 sq ft surface condenser for Oak Creek No. 3, Wisconsin Electric Power

Fig. 2. View of a power plant component seldom seen is this photo of condenser as seen from the turbine exhaust flange

Aluminum Condenser Tubes Win Out At Wisconsin Electric Power

Circulating water conditions play an important part in determining proper condenser tube material. There is no universally effective alloy. Here is experience of one electric utility with aluminum

By W. A. POLLOCK *

REPORT WAS MADE at the 1957 American Power Conference of experiences by the writer's company with a 105,000 sq ft condenser which had operated for somewhat over one year with 6061-T4 aluminum tubes. Favorable economics and other considerations provoked sufficient interest in the use of aluminum tubes to recommend that the original report be supplemented with experiences gained in the two intervening years. This was done and a supplementary report was made before the 1959 American Power Conference which furnished data for this article.

The 1957 report presented information on the first installation of its size, of aluminum condenser tubes in a central station. Tests at other Wisconsin Electric Power Co stations in condensers and steam jet air ejectors were described. First trial in a Port Washington condenser having arsenical admiralty tubes in a Muntz metal tube sheet indicated that aluminum tubes were suitable for Lake Michigan water. An air ejector test at the Commerce St Station indicated favorable performance for aluminum on the steam side and under high noncondensable gas content conditions.

Next trials in two Oak Creek condensers with steel tube sheets offered further promise of success and led to the final decision to adopt 6061-T4 alloy tubes for the third unit instead of 3003-H14 Alclad or 3003-H14 without Alclad because of apparently superior resistance to erosion and lower cost.

Full-scale installation in 105,000 sq ft condenser No. 3 was entirely satisfactory and, aside from a few failures due to a drain eroding some bottom row tubes, no troubles existed. There was some steam side erosion but this was comparable to the other two condensers with arsenical admiralty tubes of like size where stainless steel shields were clipped over the upper row tubes to protect them from erosion.

In general, the early favorable experiences in Unit 3 continue. There has been but one tube failure from either steam or water erosion since 1957. The one failure was on the steam side where erosion occurred in a tube several feet down in a lane where stainless steel shielding had not been installed. Water side erosion due to sand on the inlet end is immeasurable with the dial gage. Occasionally it is necessary to replace a stainless steel shield due to one having come off or due to erosion or vibration occurring possibly because of a change in the flow pattern.

Fourteen tubes were plugged during the summer of 1958 after two were found leaking. These tubes are located in the air cooler section of the condenser, which consists of one vertical lane of tubes being covered with a steel envelope. Vapor and non-condensable gases enter at the bottom and flow upward over the tubes. Exit to the steam jet air ejectors is at the top. Tube bundle is divided by an open area about 18 in. high, halfway between the bottom and the top. Tubes which leaked were the bottom tubes of the upper bank. Thinning was found on the bottom half of the tubes in this row. The thinning was uniformly smooth and the wasted areas were covered with a thin black tightly-adherent coating. A chemical and spectrographic examination of this material revealed both iron and aluminum oxides present. That the thinning was localized essentially in the bottom row was confirmed by tests with a Penetron thickness tester.

Determination of thinning of other tubes with the Penetron, where there was no visual thinning, was not conclusive. Tests showed a uniform thinning of ten per cent throughout the condenser regardless of location as related to steam entrance on the steam side or water entrance and its accompanying expected inlet end erosion. That such thinning has occurred is obviously questionable due to the fact that the tube section used for standardizing the Penetron was apparently somewhat thicker than the tubes being tested.

Aluminum Tubes in Feed Heaters

Unit 4 at Oak Creek gave us our first experience with aluminum tubes in low pressure extraction heaters. After only two months of operation, leaks were found in Heater 3, which is the low pressure heater on the unit which operates with a 6-psig steam pressure. A total of 25 tubes were plugged during three outages within a period of ten days. Tests revealed that an excessive pressure drop in the

* Technical Eng'r of Power Plants, Wisconsin Electric Power Co

sub-cooling section was causing flashing of condensate into steam and this resulted in erosion. Modifications to the heater reduced the pressure drop to an acceptable value and no more failures have occurred.

An inspection of this heater showed a considerable buildup of aluminum oxide on the steam side of the tubes. Iron oxide fouling on the inside of the tubes and on the heater drain pump has been greater on this unit than on any other. During the outage of the heater an attempt made to clean the outside surface of the tubes with water jets was unsuccessful, but the inside of each tube was cleaned by means of air and water jet impingement from a nozzle which was extended into the tube as far as the bend of the tube. This very effectively improved heat transfer to practically the guaranteed rate.

There is some evidence that both high pressure and low pressure extraction heater performance on Units 3 and 4 with aluminum-tubed condensers is poorer than on Units 1 and 2 with arsenical admiralty condenser tubes, due to fouling. Many heater dismantlings for modifications and repairs make it difficult to draw positive conclusions in this regard.

Unit 4 condenser was checked with the Probolog after eight months of service. No corrosion was indicated in the air cooler section where corrosion was found on Unit 3. Visually and by Probolog check, wastage was found, however, in the bottom row of tubes in the air cooler section. This general thinning was found on the bottom side of the tubes. It appeared as if condensate with corrosive properties had drained down from the tubes. Refluxing of the condensate vapors and gas was thought to be building up relatively high concentrations of ammonia. Therefore, sample connections were installed up through the hotwell which would sample condensate and gas from the areas of corrosion in both Units 3 and 4.

Samples taken to date have revealed no conditions which would account for the observed tube wastage.

Chlorination Was a Factor

Although extensive small scale tests were made prior to the adoption of aluminum as a condenser material, a certain amount of apprehension remained during the first month's commercial operation. Pilot tests had demonstrated that Lake Michigan water was not aggressive to aluminum tubes from a chemical standpoint. Actually, there never was any valid cause for worry as far as the water side of the tubes was concerned. The characteristic, tightly-adherent oxide film held up perfectly under high water velocities and was unaffected by water bearing sand and silt from the lake shore.

It is well known that the aluminum ion exhibits low toxicity to marine organisms and on the Oak Creek installations we have a vivid, though unfortunate, example. After one summer of operation, and with a chlorination program which had been found to be adequate for admiralty tubes, Unit 3 condenser was examined and found to be fouled with a lush growth of algae. After Unit 4 came into service, the same algae film appeared with a resultant loss in heat transfer rate.

The residual chlorine concentration was doubled and to this date high heat transfer rates have been maintained.

The 1957 report presented data on aluminum pickup at the hotwell of Oak Creek 3 and at the steam jet air pump. Now, two years later, we find that the aluminum concentrations are still at their low level as shown in Table I.

No morpholine determinations were made this year due to unfavorable experiences with the morpholine-carbamate test. Rather, we relied on batch feeding the morpholine and noting the conductivity and pH change.

This program was carried out on Oak Creek 4 since it was on this unit that two stainless steel probes had been installed to sample condensate from the air cooling section. The localized wastage of a few tubes in this section had prompted this action.

The probes are so cut that they bracket the lower bank of tubes in the air cooling section. Samples when analyzed showed no difference in aluminum content (0.04 ppm), but did show a variation in pH (7.4 and 8.8) and total ammonia content (0.2 and 0.5). In both cases the higher values of pH and NH_3 came from the lowest sample point.

While this data is far from conclusive it tends to reinforce the belief that high localized concentrations of NH_3 and CO_2 can occur in the air cooling section and result in a corrosive environment.

Of equal interest is the behavior of aluminum in regions of elevated temperature. One of the low pressure heaters with aluminum tubes showed a considerable buildup of non-adherent powdery aluminum oxide. Drain pump for this heater experiences a rapid buildup of iron oxide and there is a very rapid deposition of iron oxide on the inside of the tubes. This problem does not seem as acute in the two other lower pressure-lower temperature heaters.

Steam jet air pump, also working at higher temperatures, shows more aluminum pickup than the condenser and seems more susceptible to morpholine or ammonia concentrations.

Fear of analcite scale formation on boiler tubes has not been substantiated. Aluminum which gets into the boiler remains as sodium aluminate because on load drops the boiler water concentrations increase and aluminum is found in suspension. If aluminum were forming scale, no increase would be found. Oak Creek boilers 1 to 4 are controlled circulation boilers. No buildup is found on the orifices and the pressure drop across the orifice remains constant. Normally the aluminum content in the boiler water is below 1.0 ppm.

Table showing data on aluminum pick-up at hot well and at steam jet air pump

Test No.	Unit No.	Sample Source	pH	Al ppm	NH_3 ppm	Specific Resistance Ohms
1	3	Hotwell	8.7	0.03	0.26	600,000
		SJAP	7.1	0.03	3.2	50,000
		(Morpholine concentration approximately 3 ppm)				
2	4	Hotwell	8.4	0.04	0.4	500,000
		SJAP	7.0	0.05	10.0	42,000
		Air Cooler	7.1	0.02	1.1	
		3 htr. drain	8.6	0.06	0.5	
		(Morpholine concentration approximately 2 ppm)				
3	4	Hotwell	9.0	0.04	0.58	270,000
		SJAP	9.0	0.1	9.6	15,000
		Air Cooler	7.4	0.04	0.2	192,000
			8.8	0.04	0.52	147,000
		(Morpholine concentration approximately 6 ppm)				

Some Design Considerations

The continuing race to meet the challenge of supplying the power requirements for a nation which doubles its usage every ten years creates many problems. Capacity of the units being installed is of necessity increasing at a rapid rate. To provide the same percentage increase in capacity on a given system in a single unit, it is necessary to build the units twice as large as a decade ago. Units of 450 and 500 mw are on order at the present time.

To meet the challenge of providing adequate condensing capacity a myriad of new problems arises. A few are enumerated as follows:

1. Condenser space is limited by foundation designs and crowding results.
2. Large machines require more condensing surface which requires crowding condenser tubes closer together.
3. Weight of the larger condensers becomes a support problem.
4. There is an economic limit to the length of condenser tubes.
5. Turbine and preboiler cycle

drain disposal problems increase as drain quantities increase.

6. Higher pressures and temperatures of modern practice necessitate better water treatment. Materials in the condenser must be compatible with the chemical treatments.

7. High investment costs and the cost of furnishing adequate capacity during outages call for designs that keep outages to a minimum and which facilitate repairs to keep down-time to an irreducible low.

The first conclusion in the 1957 paper included a recommendation that trial installations to determine suitability of aluminum tubes be made before adopting them for new installations. This is still considered extremely desirable. Testing for effect of circulating water on aluminum and testing for steam side conditions is equally desirable. Steam velocities and flow patterns need be evaluated. Restrictions in the condenser entrance can change flow patterns and produce unfavorable cutting of tubes. If trial tubes are put in older condensers for test, one must realize that the conditions will be different in the new larger design, and must take this into account. Erosion varies with the third to sixth power of the velocity. Some unpublished work indicates erosion varies to the sixth power of velocity with turbine blade material. There is considerable evidence that 6061-T4 alloy is more resistant to erosion than 3003-H14 and some others.

Economics of covering the top rows of aluminum tubes with stainless steel shields has been compared with substituting stainless steel tubes in the critical areas with the conclusion that the stainless tubes are cheaper. This decision assumes that there is no problem of erosion at the tube support plates and ends of shields.

Circulating water flow conditions change and water-box erosion patterns change. A drop in Lake Michigan level of several feet over a period of years increased velocities in the intake channel at our Port Washington station. Sand and silt picked up by this increased velocity caused erosion on the arsenical admiralty tubes which was severe enough to require protection of these tube ends with polyethylene inserts. Adding another large unit to an existing flow channel may well increase velocities to a degree which would create a like erosion problem. Should this be the initial installation of aluminum tubes, the tube material would receive blame for erosion resistance where in reality other tube materials would have suffered the same damage.

Crowding considerably more condensing surface into the condensers by rearranging the steam lanes, placing tubes closer to the turbine exhaust, and closer to the condenser hotwell, has made designing for disposal of drains more difficult. There was a time when drains were disposed of by running the drain line to the condenser by the easiest route and tapping into the condenser shell. Now with less clearance and with the quantity of drains being greater, the problem of disposal of drains merits a closer look. The writer's company has decided to route most of the drains to two flash chambers, one for high pressure and the other for low pressure. Flash from these flash chambers will be put into the condenser above the tubes while the drain is led in near the hotwell. Much of the erosion due to inadequate baffling is thereby eliminated. This consideration is desirable regardless of condenser tube material. Special attention is being given to prevent drains entering where they could cause splashing of condensate onto tubes and support plates. Adequate baffling is being planned to preclude this possibility.

Summary and Conclusions

Aluminum condenser tubes continue to prove satisfactory for central station service under Oak Creek conditions.

Oak Creek 5, which is now under construction, will have two condensers with 6061-T4 aluminum tubes. The main condenser will have 159,000 sq ft and the boiler feed pump turbine condenser 5250 sq ft. Top row tubes and other tubes where erosion or corrosion troubles may be expected based on past experiences will be of stainless. As indicated elsewhere, this is more economical and has other advantages over aluminum tubes with stainless shields.

Low pressure extraction heaters and steam jet air ejectors will again have aluminum tubes.

Trial installations are recommended before adopting aluminum tubes.

Careful design to reduce operating problems are necessary regardless of the type of tube material. It can safely be said that there is not one universal tube material. THE END

Lightning Protection—The Approach Today

By H. R. ARMSTRONG*

WITH industry acceptance of standard Basic Impulse Insulation Levels it became possible to consider equipment in terms of definite impulse voltage strengths for direct comparison to arrester protective levels. Overvoltage protective practices have evolved from a consideration of "insulation coördination" to what might be called "coördination of protective devices."

The factors to be considered in today's approach to the over-voltage protection of stations problem, in the broadest sense, and their relation to each other, are as follows:

The best arrester protection is obtained by the use of the lowest voltage rating possible. This voltage rating must not be less than the highest phase-to-earth power frequency voltage allowed at the arrester location by the system grounding and circuit configuration.

The location of the arrester relative to the insulation to be protected influences the protective level at the insulations. For the case of an arrester at a line entrance, the voltage may be higher at the other end of the bus. Conversely, the transformer arrester may allow a higher voltage at the line entrance equipment.

After the arrester rating has been determined, and the voltage at the equipment location has been determined from the arrester characteristic and location, the lowest protectible BIL (Basic Impulse Insulation Level) suitable for the system can be selected.

As an example, consider a 138-kv system that is effectively grounded. Using the simple 80 per cent rule, the maximum phase-to-ground voltage will be, based on 105 per cent of the nominal voltage, 117 kv, which requires a 121-kv arrester.

On the most severe assumption that only one well-shielded line remains connected to a station bus, and considering the usual dimensions of a 138-kv station, arresters at the line entrance and the transformer allow at any point in the station a maximum voltage of about 110 per cent of the arrester sparkover. As the sparkover voltage of the station-type 121-kv arrester is about 400 kv, which is higher than the discharge value of about 350 kv, the highest voltage in the station will be 110 per cent of 400 kv or 440 kv. This indicates a station BIL of 450 kv or two steps down from the "full" level of 650 kv, neglecting the question of the power-frequency stress.

It is evident, then, that the terms "full" or "reduced" as applied to insulation BILs are misnomers. Actually, any insulation level that can be protected by a lightning arrester is the full level for the conditions considered. Conditions have changed to the point where today it can be visualized that arresters can protect a lower level of insulation than was possible a short time ago.

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* Detroit Edison Co. These remarks are taken from a paper on Lightning Protection for Electrical Equipment—Its Developments and Present Status, given by Mr. Armstrong at the 1959 American Power Conference

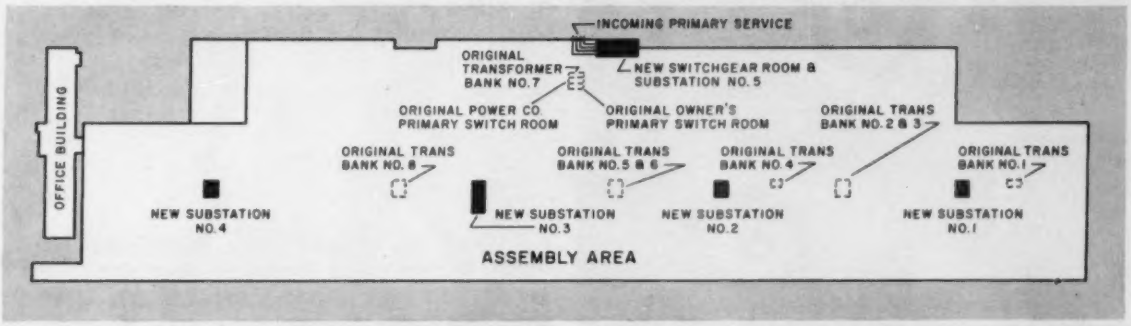

INCOMING PRIMARY SERVICE
ORIGINAL TRANSFORMER BANK NO. 7
NEW SWITCHGEAR ROOM & SUBSTATION NO. 5
OFFICE BUILDING
ORIGINAL POWER CO. PRIMARY SWITCH ROOM
ORIGINAL OWNER'S PRIMARY SWITCH ROOM
ORIGINAL TRANS BANK NO. 2 & 3
ORIGINAL TRANS BANK NO. 8
ORIGINAL TRANS BANK NO. 5 & 6
ORIGINAL TRANS BANK NO. 4
ORIGINAL TRANS BANK NO. 1
NEW SUBSTATION NO. 4
NEW SUBSTATION NO. 3
NEW SUBSTATION NO. 2
NEW SUBSTATION NO. 1
ASSEMBLY AREA

Fig. 1. Roof plan of main assembly building, showing locations of original transformer banks and new unit-subs. In this plan, five centers replaced eight original banks of equipment. Note Substation No. 5 combined with incoming primary switchgear

Good Planning Smooths Out Power Conversion in Auto Plant

Good engineering and planning permit auto manufacturer to modernize electrical system with little effect on production schedules. Here's a detailed account of how Plymouth-Detroit Plant replaced outmoded system with modern one, and gained needed reliability

By JOSEPH R. HENNIGER *

CHRYSLER'S PLYMOUTH-Detroit Assembly Plant, located in the heart of Detroit, was originally built during the early part of 1925, and contained an area of approximately 418,000 sq ft. Over the years, this plant has more than tripled its size until it now covers an area of nearly 1,400,000 sq ft, exclusive of an attached two-story office building and miscellaneous auxiliary buildings, and is one of the major automobile assembly plants located in Michigan. The factory portion alone is 2400 ft long and varies in width to a maximum of 580 ft.

As this vast plant grew, so did its electrical load requirements, which dictated modifications, additions, and extensions to the primary and secondary distribution equipment (and feeder systems) serving the complex of buildings comprising the plant. One of the most important modifications required was the relocation of all the step-down power and lighting substations, including the main primary switch-house from the interior of the factory building (at ground level) to the roof. These substation areas were relocated approximately 20 years ago to provide additional valuable floor space for manufacturing facilities; and, significantly, the change was accomplished during regular working hours without interruption to production.

About 18 months ago, the Chrysler Corp management approved a huge facilities conversion project which, when finished, will completely replace a large portion of their existing manufacturing equipment and processes. It was considered expedient, therefore, to arrange for a thorough check on the plant's electrical distribution system. At that time, Albert Kahn Associated Architects and Engineers were called in to make a survey of, and report on, the complete primary and secondary distribution system in use.

Incoming primary service was obtained from the Detroit Edison Co substation located on adjoining property of the Chrysler Corp. This substation contained four 10,000-kva, 3-phase, step-down transformers, from 24,000 to 4800 volts, one of which was a standby. In addition to serving the Plymouth plant, this substation served four other Chrysler plants in the immediate vicinity. The incoming service consisted of three underground feeders, each having a nominal rating of 6000 kva. Each feeder terminated on a main bus through an 800 amp oil circuit-breaker of 150,000-kva interrupting capacity, located in the main switch-house on the roof of the plant. The main breakers formerly were manually-operated but had been converted to remote electrical operation.

Each power and lighting transformer bank was fed radially, through a three-pole, 600 amp, manually operated branch feeder oil circuit-breaker, which was used for disconnect purposes only. Each of these breakers had its respective overload and tripping mechanism removed, as the breaker interrupting capacity was only 25,000 kva. In order to provide some means of flexibility and load balance on the three incoming services, each of these breakers was connected to the center pole of a double-throw disconnect switch which, in turn, was connected to two of the main incoming buses.

Each power transformer bank consisted of three single-phase, delta-connected transformers, varying in capacity from 250 to 600 kva, which provided three-phase, secondary service at 460 v for factory use.

In general, each lighting transformer bank consisted of one, single-phase transformer, varying in capacity from 200 to 333 kva, which provided single phase, three-wire service at 115/230 v for factory use. All banks were located on concrete platforms above the roof, and generally combined both power and lighting transformers on the same slab.

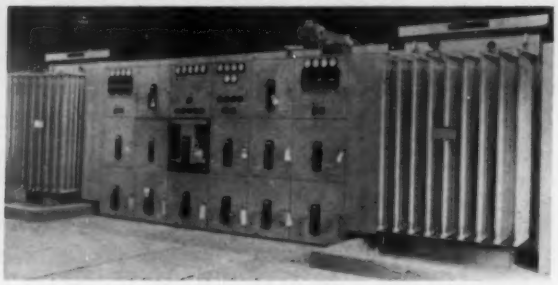
The main secondary switchboards were located on the roof, under their respective transformer banks, and consisted of oil circuit-breakers mounted on slate panels of free-standing open pipe frame construction. The individual breakers were of antiquated design and did not have adequate interrupting capacity. Fortunately, this equipment (see Fig. 2) was never required to open under short-circuit conditions.

The basic lighting and power secondary distribution systems consisted mainly of three single-conductor open feeders, installed *in-line* on insulators in the truss and/or monitor areas of the plant. These systems, in turn, were connected to their respective oil circuit-breakers, located in the switch rooms under

*Associate, Albert Kahn Associated Architects and Engineers, Detroit.

Fig. 2. One of original secondary switchboards serving the plant; is typical of most installations of the same vintage

Fig. 3. Front view of typical modern, double-ended unit substation. This type used to replace switchgear shown in Fig. 2



the transformer decks on the roof. Voltage regulation was very poor, as a consequence of the inherent feeder configuration installation and extremely long runs. Fundamentally, the feeders were connected as a straight radial distribution system. However, installation of numerous manually-operated disconnect switches permitted the isolation of their original source of feed, and extended (and connected) to a different source of feed. In addition to the open feeders which ran the length of the building, plug-in type bus duct was installed in the concentrated power load areas, extending the width of the building, and was connected to the open power feeders.

The lighting panels were mostly of the switch-and-fuse type, usually mounted immediately below the bottom chord of the truss, and were heavily overloaded and accessible only with difficulty. In order to provide switching facilities for various lighting requirements, gang-type, single-pole switches were located on columns, within reach from the floor throughout the plant. As the lighting requirements grew, and all spare circuits in the panels were utilized, the gang-type switches were then connected to fuse blocks located in the truss areas.

These conditions existed in a major portion of the plant. In certain areas, however, modern narrow *column-type* panels were in use.

During the survey and preparation of the report, it was found that despite the obsolescence and condition of the equipment, the system was functioning and had been in service for years. The major questions to be resolved were:

1. How long would the electrical system continue to operate without serious interruption of production?

2. What should be done to correct and/or replace the existing equipment in the plant?

3. How much would renovation cost for the total system?

When management was presented with all the facts and conditions of the plant's existing electrical distribution system, including probable life expectancy, recommendations and costs, they unhesitatingly authorized a complete renovation program. Description of how this program was accomplished follows.

In a factory the size of Plymouth-Detroit Assembly Plant, the adoption of a 13.2-kv primary distribution system was indicated. Not only this plant, but three other Chrysler facilities in the immediate neighborhood were, at the time of this renovation, supplied with primary service at 4800 v. This came from the power company's modern substation, which was specifically designed for, and of adequate capacity to serve and meter, this complex of buildings as a single unit. In addition, this substation, located on adjoining property,

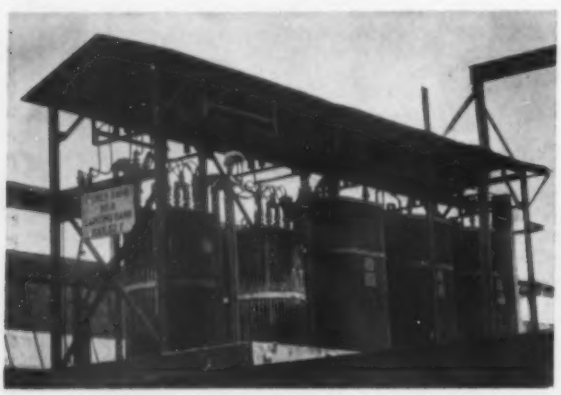


Fig. 4. View of an original transformer bank on roof of building. Modern switchgear replaced these substations

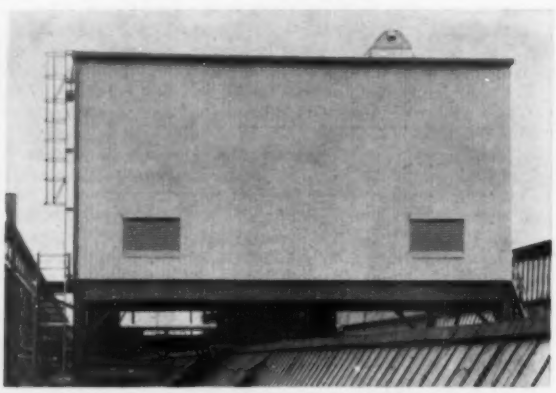
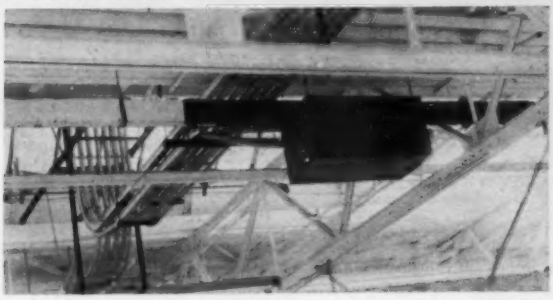


Fig. 5. One of new penthouses built to house switchgear. Primary conduits, armored-cable secondaries, at bottom

Fig. 6. Typical example of modernization. Note narrow lighting panel, installed in web of column, and old panel above

Fig. 7. Final results of modernization program. Secondaries, in armored-cable on racks, feed plug-in bus duct laterals



served the plant via underground feeders, having a total capacity of 18,000 kva. Since these feeders were in good condition and of ample capacity, it was considered both practical and economical to retain the existing 4800-v service.

The major consideration throughout the entire design was to maintain production. This is no small achievement under normal conditions. Coincident with this particular modernization program, however, management was planning a huge facilities conversion program, which required the revision and relocation of certain process layouts in the plant for new model change-over requirements. How this was accomplished during the actual installation is not part of this article but illustrates the coördination required.

Also, as a result of the process modifications occurring in various sections of the plant, production in the affected areas naturally came to a halt. Advantage of this condition was taken to install, remove, and/or relocate as much as possible of the equipment involved in the modernization of the distribution system. It was, of course, impossible to complete the installation without brief shutdowns. However, by establishing and maintaining exacting time schedules, and with the fullest cooperation of all parties concerned, both overtime and shut-downs were kept at a minimum.

The original transformer installation for the factory area consisted of eight power banks and five lighting banks (some of which were combined in six different locations on the roof), totaling 31 single-phase transformers with a kva capacity of 13,750. (See Fig. 4.)

New transformer locations were required because there was inadequate space for the installation of new equipment in existing locations. In addition, relocation of the transformer areas served to prevent any possible shutdown or loss of service. In order to support the new equipment and its necessary structural housing in new locations, reinforcing and extension above the roof of the building structural columns was required. (See one of the new substations in Fig. 5).

Design of Substations

The new transformer installation was designed to be housed in five separate structures located on the roof. Two of the new structures enclose single 3000-kva double-ended unit substations each; a third structure encloses two 3000-kva double-ended substations; a fourth houses the primary incoming and distribution switchgear in one portion, with two-1500-kva single-ended type unit substations and a production equipment motor control center in an adjacent portion. The fifth structure consists of a modified existing enclosure, housing two 3000-kva double-ended unit substations. Actually, 14 three-phase, 480-v power transformers, totaling 21,000 kva, were installed in the above structures, with space provisions made for future installation of an additional 6000-kva unit, if and when required.

The assembly plant, as shown in the roof plan, is rectangular in shape and is more than four times as long as wide. Since the assembly of automobiles is the prime function of the plant, there were no large general (or concentrated) load requirements needed or anticipated, except for painting and welding. Thus, four of the new substation locations were chosen to provide an evenly-distributed load for the entire plant. Each of these substation structures was designed to accommodate two 3000-kva double-ended unit substations, although only one unit was initially installed for present building use. The fifth substation was located near the painting area, to accommodate this concentrated load, consisting of pumps, blowers, and auxiliary equipment. Two 3000-kva unit substations were provided, one in each of two of the above building substations, to accommodate the welding needs.

Following determination of the number, size and location of the substations required, together with the incoming service requirements, the primary distribution system was designed. The original incoming primary service entered the building approximately at its midpoint from the railroad side and was distributed via an underground duct-and-manhole system. As all of the original transformer banks, including the main switching station, were located on the roof, the individual feeders serving this equipment were extended in conduit risers located in the column webs.

In the later design, this whole system of branch-feeder distribution was abandoned, as it was impossible to tie into, or extend, the system without extensive excavation and interference with assembly operations.

New primary feeder distribution system was routed over the roof monitors, from the primary switchgear to the various substations, on specially designed racks, which supported conduit-encased lead-covered cables. (See Fig. 8 for a section of the primary feeder runs.) All cable runs were protected from the direct rays of the sun by a galvanized sheet-metal roofing over the conduits.

A new manhole was built into original incoming underground duct line, immediately outside the building, from which new service cables (in a conduit bank) were installed on

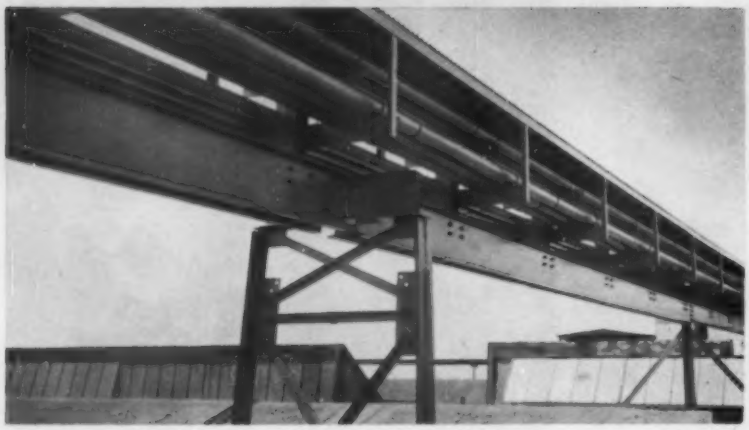


Fig. 8. Specially designed racks support primary feeder distribution system over roof monitors. See sunshine roof which keeps direct rays of sun from conduits

the exterior face of the building, up and over the roof to the new primary switchgear. Thus, the entire new primary feeder distribution system could be installed during regular working hours, without interference with the existing installation or shutdown of electrical service to production or building utility equipment.

One of the problems involved the design of the primary distribution system in order to maintain service during a model change-over. It meant the routing of a body paint oven directly through the existing primary switching station. This was accomplished by first installing (and energizing) the new primary switchgear and routing temporary armored-steel cable feeders across the roof. Actually, the oven pierced only the main incoming-breaker portion of the switch house and did not interfere with the branch feeder breaker section of the installation.

Primary Switchgear

The primary switchgear was designed for normal operation of three incoming services, each feeding approximately one-third of the total plant load. Each service is equipped with main (and branch) feeder breaker, connected to its adjacent service through a normally-open bus tie-breaker. In the event of an outage on one incoming feeder due to loss of voltage, the main breaker is designed to drop out, and the bus tie automatically closed, thus restoring service to that portion of the plant. Restoration of voltage automatically transfers all breakers back to normal operation without service interruption. In the event of over-current tripping of a main breaker, the automatic bus-tie transfer is blocked and, of course, service to that section of the plant is interrupted until the fault is located and isolated. In addition to fully-automatic operation, provision is made for complete manual-operation by means of a selector-switch, which nullifies all automatic control. The primary feeder-cable distribution system is of the *radial type*, with each feeder serving two halves of different unit-substation transformers. Thus, each unit-substation is served from two different incoming service feeders. This arrangement provides maximum flexibility of operation.

Unit Substations

Each of the new unit-substations is of the typical modern, dead-front, double-ended type (see Fig. 3). It has a total capacity of 3000 kva, using delta-wye connected three-phase, askarel-filled, self-cooled transformers; 4800-v primary and 480/277-v grounded secondary. The secondary switchgear section contains draw-out-type air circuit-breakers, with electrically-operated main and "normally-open" tie-breakers.

Both main and tie-breakers are key-interlocked with their respective primary air-type disconnect switches to permit complete operation through one transformer for emergency and reduced loading conditions in event of transformer or primary-cable outage.

Secondary Distribution

Plant's first secondary distribution system included open feeders, installed in the truss area, running lengthwise of the building. They fed approximately 8000 ft of plug-in type bus duct, installed at right-angles to the open-feeder system. The new secondary distribution system utilized all of the original bus duct, and required approximately a 70 per cent increase in total footage. In general, it consists of 400 amp and 600 amp plug-in type bus duct, with continuous runs the length of the building on 80 ft centers. Each length is fed from several different substations along its route, with interlocked-armored cables from the secondary switchgear.

Bus is sectionalized by means of isolating joints, so that only one portion of the bus is fed from any one particular substation. The isolating joint can quickly and easily be positioned at any 10 ft splicing joint along the entire bus run. This feature provides a tremendous amount of flexibility for loading and/or balancing of the whole system. The entire original bus duct installation was not only removed but inspected and repaired as required, before it was re-installed in the new layout. Fig. 7 shows a typical installation of armored-cable secondary feeders, dropping down on cable racks from the substation above and feeding one section of the bus duct run. In addition to this distribution system, a 2000 amp, low impedance, plug-in type bus duct installation provides service for all body-welding.

Secondary electrical service continuity was maintained by utilizing the original open-feeder installation and providing temporary jumpers to energize the new bus duct distribution system, as it was installed, to reduce outage time to a minimum.

Transfer of each individual load from its original source of supply to the new source was accomplished in accordance with a strict time schedule, with all materials in place, completely ready, except for the actual cut-over and/or connection. All building utility equipment motors, plus lighting fixture circuits not affecting production, were then cut-over during regular working hours. Production motors and lighting circuits in production areas were changed-over during normal down-time.

Lighting Service

Inasmuch as the original lighting service was single-phase, three-wire, 115/230 v, and all of the panels were designed for this type of distribution, it was decided to retain this class of service in the new lighting distribution system. From preliminary surveys, it was determined that approximately 50 per cent of the original lighting panel installations could be reused as they were of modern column-type. All new panels selected were of similar type and were increased in circuit-capacity. Each panel is fed from a dry-type, single-phase transformer, located in the truss space, and is fed from the general power bus duct installation. Fig. 6 shows the typical manner in which the lighting service was maintained (by pulling the original panel away from the column to permit installation of new column-type lighting panel). When the new panel was completely installed and energized, the circuits, one by one, were transferred, and finally the old panel was removed in its entirety.

Principal credit for the successful execution of this renovation program belongs to the following: W. Allen and H. Hunt of the Chrysler Corp; E. Russell, R. Puckett and T. Weedmark of the John Miller Electric Co; H. Ibler of the Detroit Edison Co; and P. Best and I. Reif, field superintendents for Albert Kahn Associated Architects and Engineers, Inc., Detroit, Mich. THE END

Chincoteague Goes To Dual-Fuel Firing

Flexibility of operation is important to Navy shore installations to meet wide variety of possible future conditions. To anticipate them, this Naval Air Station converts existing boilers, installs a new one, all for dual-fuel firing with oil or coal

Fig. 1. Central heating plant at Naval Air Station, Chincoteague, Va. Boiler can be skidded in or out through door

By DENARD L. GUSLER, P.E.*

CENTRAL HEATING plant at the U. S. Naval Air Station, Chincoteague, Virginia, was first put into operation December 5, 1944. Building is a brick structure and has an installation of four Babcock and Wilcox bent-tube, type H, Stirling boilers with radiant wall furnaces, each rated at 265 boiler hp. The furnaces were fired by Canton Model 8U32 single retort stokers. Mechanical draft was furnished by forced draft fans and induced draft fans in venturi stacks.

Coal was stored adjacent to the heating plant in a storage area having a capacity of approximately 2000 tons. A coal silo was located at the north corner of the building and had a 59 ton storage capacity in the top and 200 ton capacity in the bottom. Coal was delivered to the stoker hoppers by means of a weigh lorry of 1800 lb capacity. Ashes were removed manually and hauled by wheelbarrow to the rear of the plant.

Steam was generated at 130 psig in winter and 120 psig in summer and was piped to the various buildings where pressure was reduced. About 50 per cent of the steam was returned to the heating plant. Boiler make-up water was drawn from the station water system, and treatment was not required as the $CaCO_3$ hardness varied from zero to 1.5 grains per gal. The 6.5 pH corrosive effect was neutralized by phosphate at the source.

A receiving tank of approximately 1300 gal. capacity was located just under the roof of the heating plant. Condensate from the buildings was pumped to this tank and by gravity from the receiving tank to the feed water heater.

*Clark, Buhr & Nexson, Architects-Engineers

In December 1951, a report and evaluation of this plant was prepared under a Navy contract which included a detailed study of projected loading of the plant resulting from future construction. Findings in the report indicated that the size of coal burned in the boilers resulted in reduced boiler efficiency and increased stoker and boiler maintenance costs.

Conversion Increases Capacity

Coal used was practically all slack and too fine for the method of firing. Slacked coal packed in the firebox and required frequent slicing to support combustion. Several small explosions had occurred in the combustion spaces of the boilers, causing the brick settings to bulge outward. Brickwork of the boilers needed replacing. Slack coal was packing in the retorts of the stoker mechanism and causing frequent breakdowns. Packing of the coal was causing fluctuating steam pressures.

By a detailed study of existing structures it was found that the steam load at that time was 36,000 lb per hr. With proper size of coal and stoker firing, each boiler had a continuous capacity of 16,000 lb of steam per hr. With three boilers in service, the total capacity of the heating plant was 48,000 lb of steam per hr which allowed for one boiler to be out of service at all times. It was determined that if the existing boilers were converted to oil firing, capacity of the boilers could be increased. Each boiler had a circulation limitation factor of 6.6 lb per sq ft heating surface, which at 2650 sq ft equaled 17,500 lb per hr maximum continuous output per boiler. With three boilers in service, the total capacity would be 52,500 lb per hr.

Projected load resulting from anticipated construction indicated that a plant capacity of 47,000 lb per hr with one boiler out of service would be required. Based on the foregoing report the existing boilers were converted to oil firing. Rotary cup burners, utilizing No. 6 fuel oil, were installed, as shown in Fig. 3, with related auxiliary equipment and other renovation work in the plant to provide a more efficient operation. Oil burners are Ray horizontal rotary units, type AG 104. Essential features of the coal handling and storage equipment were retained so that the boilers could be converted back to coal firing in the event of a fuel oil shortage.

The renovated plant has functioned efficiently to furnish steam as required. In 1955 it was determined that additional station load, resulting from proposed construction of an infirmary, hangar, special projects

Table defining minimum requirements for Navy's dual-fuel steam generators

(a) HEATING SURFACE	
(1) Boiler	1840 sq ft
(2) Water Walls	900 sq ft
(3) Economizer	938 sq ft
(b) FURNACE VOLUME	1680 cu ft
(c) GUARANTEED EFFICIENCY—78% based on bituminous coal as follows:	
Volatile	24–35%
Moisture	2–10%
Ash	5–10%
Btu as fired	12,000 to 14,000
Ash softening temperature	2,000 F
Sulphur	3%
(d) GUARANTEED EFFICIENCY—80% based on Bunker—C fuel oil as follows:	
Sulphur	0.72%
H_2O	10.27%
Carbon	88.43%
N_2	0.36%
O_2	0.22%
Btu as fired	18,500

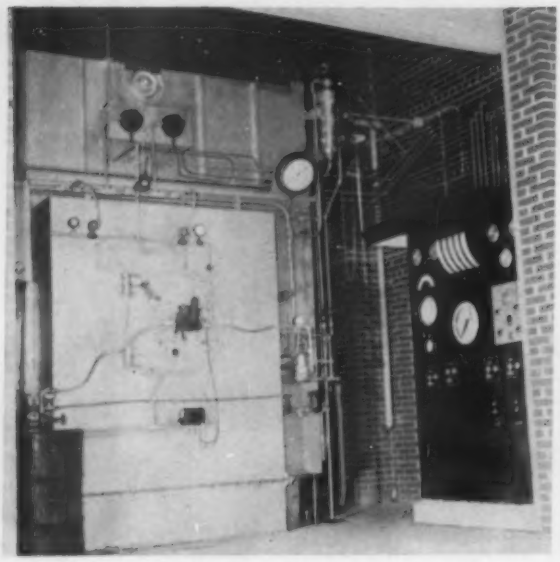


Fig. 2. New boiler, operated at 125 psi, is oil-fired and has mechanical arrangement for rapid conversion to coal

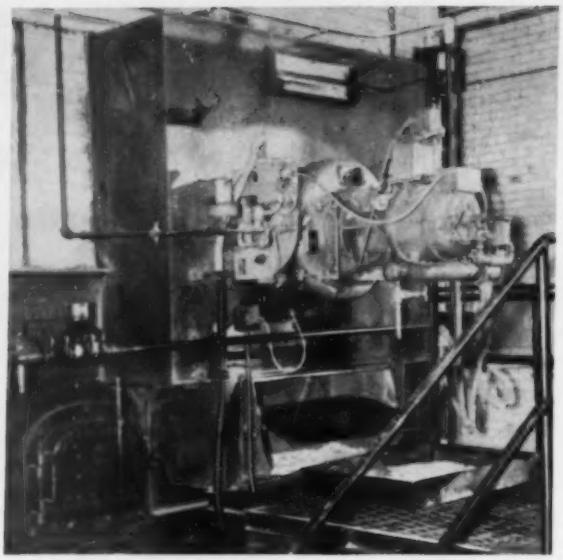


Fig. 3. Older boiler after conversion. All units in plant can be shifted from oil to stoker firing within 48-hr period

building, and fire control building, would necessitate a boiler plant addition to the central heating plant.

In September 1955, our firm was awarded the contract, which included the preparation of contract plans and specifications for an addition to the Central Heating Plant of the U. S. Naval Air Station, Chincoteague, Va. It was immediately apparent that a dual-fuel package-type boiler should be provided. The unit should be oil fired with mechanical arrangements that would permit speedy conversion to coal firing. This feature would be particularly important since coal storage and transport facilities existed and were operable.

The dual-fuel oil-coal package-steam generator that was installed in the Central Heating Plant addition is shown in Fig. 2. Boiler was designed and constructed by the Wickes Boiler Co. It is equipped with a Todd Model D oil burner. It is one of the first dual-fuel oil-coal package units ever built and is unique in that it was not built under a development contract but in accordance with the requirements of an ordinary project specification.

It was specified that the boiler meet the requirements of NavDocks Specification No. MIL-B-17095B for Type I boilers, except that the boiler should be the standard product of the manufacturer for dual-fuel firing of oil and future coal. This specification was written by the Bureau of Yards and Docks for Boilers, Steam, High Pressure (water tube, package type, 5,000 to 35,000 lb per hr, with oil, gas, or combination oil and gas firing). It was further specified that the boiler should conform to the minimum requirements shown in the accompanying table.

It was required that the fly ash separator be a part of the package unit to include the induced draft fan, induced draft fan drive, and stack, rigidly framed as a unit. Fly ash hoppers were to be provided and blanked off for the future installation of a fly-ash re-injection system.

Converts Within 48 Hours

Perhaps the most difficult requirement was that provision should be made for the future installation of a spreader stoker of the vibrating grate type, front continuous ash discharge, future fly-ash re-injection system, and all appurtenances as required for future firing of coal. All arrangements were to be such that initial mechanical and electrical conversion from oil to coal could be completed within a 48-hour period. (See POWER ENGINEERING for January, 1956, for complete report on this requirement.)

Capacity of the boiler was specified to be not less than 30,000 lb per hr continuous duty, 125 psi operating pressure, 250 psi design pressure, feed-water temperature 220 F, economizer outlet temperature 288 F, steam temperature saturated, ambient air temperature 80 F.

Combustion control system was to be completely automatic and of the full metering type with electronic supervision of the oil flame.

Foundations of the boiler were to be a flat concrete slab without any elevated or indented bearing surfaces.

The resultant boiler as constructed and installed is shown in Fig. 1.

Boiler package is approximately 11 ft wide; 13 ft, 10 in. high; and 27 ft long. Induced draft fan package is 12 ft, 6 in. long; 10 ft wide; and 16 ft high. Boiler package was shipped complete except for minor trim, so that it could be skidded into place on any smooth surface in a short period of time. Induced draft fan assembly was shipped complete for flange bolting to the boiler outlet and connection to the steel stack which it is designed to support. Both units were designed for railroad clearances and can be readily relocated to another site.

To achieve maximum operating efficiency, the combustion control panel, also shown in Fig. 2, was specified and constructed. It included all necessary draft and pressure gages; steam flow recorder, indicator and totalizer; CO_2 indicator and recorder; flue gas recorder; electronic flame monitoring controls and master steam pressure controller.

Also included were manual-automatic sub-panels for boiler fuel, forced and induced draft fans, fuel-air ratio, and start-stop stations with indicating lights for forced and induced draft fans. Space was left for future installation of stoker controls and associated instrumentation.

Central heating plant building addition was designed for the extension of the coal transport equipment in the event the boiler should be converted to coal firing. Doorway was sized to permit installation of the boiler unit after the building construction was completed. THE END

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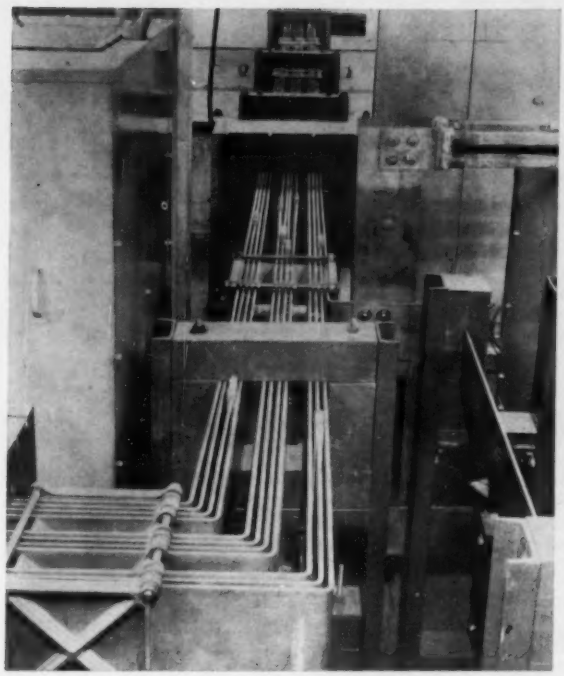


Fig. 1. Bus-bar run. Note normal spacing and random lengths

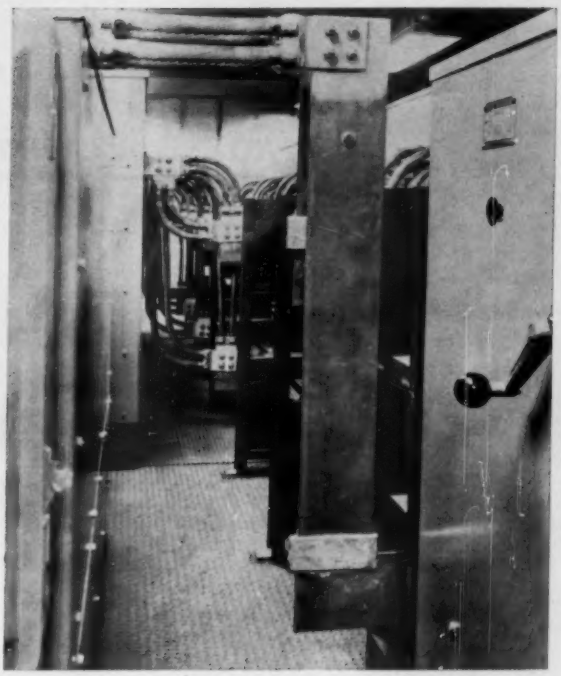


Fig. 2. Rectifier jumpers consist of cables welded to lugs

Butt Welding Conductors Cuts Cost

WHEN THE STEEL and Tube Division of the Timken Roller Bearing Co recently installed a consumable-electrode vacuum melting furnace, many pounds of copper were saved by the use of butt welding on the bus bars. Electrical installation consists of a 25,000-amp d-c bus system fed by nine 2500-amp rectifiers and two 1250-amp line-balancing rectifiers.

Bus bars consist of twelve 5/16 by 8-in. copper bars on both the positive and negative runs, each of which is approximately 50 ft long.

Use of the butt-welding scheme, called Cadweld, permitted random lengths of copper to be joined, eliminating much of the labor of cutting and all waste. Further, the 8-in. lap that would have been required for lap joints was saved. When two welds are made at one point, the overall weld thickness is equal to a lap joint.

Cadweld connection is an exothermic reduction of copper oxide by aluminum in which no outside source of power or heat is required. Equipment necessary consists of a mold machined out of graphite, with an upper and a lower chamber. Upper chamber houses the welding powder prior to ignition by a flint-gun spark. Conductors to be welded are housed in the lower chamber.

On ignition the powder becomes molten and flows down over the conductors, melting them into a solid, homogeneous mass. The connection is completed before the heat is dissipated by the conductors.

Aluminum and aluminum-to-copper connections can also be made by this process. THE END

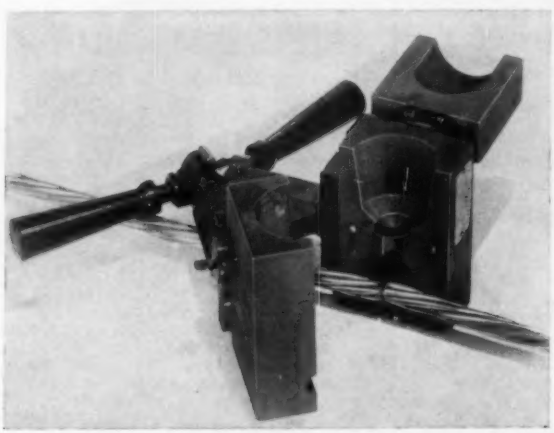


Fig. 3. Preparation for welding. Three-part mold is graphite

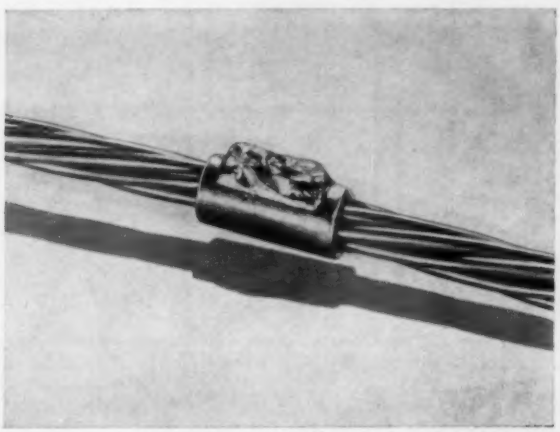


Fig. 4. Completed weld is strong and has high conductivity

Industrial Power Plant Accounting

By JOHN S. COLE, P.E.

Earlier articles in this series told how to set up cost accounting systems for industrial power plants and how to use data for apportioning departmental charges. Mr. Cole now explains how . . .

Accurate Records Cut Operating Costs

MOST POWER ENGINEERS regard paperwork and the endless details entailed in such work with the greatest distaste. They tend to push the paperwork aside, to be taken up only when other, more attractive work in operation and maintenance has been completed. This is a wrong attitude, for good records are one of the best foundations on which to build a well-operated power department.

A complete set of cost and performance records is a must for any successful utility manager. He must constantly refer to these records to check his performance and to control operating costs.

These figures and records are the basis on which he predicts his future performance and sets his operating cost budgets. They also are extremely necessary to form a justification for requests for new installations, or to replace worn or obsolete equipment.

Most power departments operate on a break-even basis. Particularly is this true in plants with multiple producing departments. Expense recovered from sales of utilities should nearly balance the overall cost of generating and distributing utilities to those sections.

Assume a power plant similar to the one diagrammed in Fig. 1 is operated to furnish utilities to the plant producing sections. Two questions immediately become apparent: A. *What should it cost to operate such a plant* and, B. *How can the sales of utilities cover the cost of such an operation?*

Plant production sections require the following utilities for their operation: 1. Intermediate pressure steam for process and heating; 2. Low pressure steam for process and heating; 3. Alternating current for lights and power; 4. Compressed air for process and manufacture; 5. Plant-treated water for process; 6. City water for drinking and domestic service; 7. Public utility power to supplement generated power; 8. Waste treatment or sewage disposal to city sewage.

In order to produce and distribute these services, the utilities section requires facilities to produce: 1. High-pressure steam for station service and power generation; 2. Intermediate-pressure steam for station service and power production; 3. Low-pressure steam for station service; 4. Alternating current for station service; 5. Compressed air for station service; 6. Plant-treated water for station service.

From the steam requirements as shown in Fig. 1, it is seen that 937 million lbs of high-pressure and 219.9 million lbs of intermediate-pressure steam are to be generated.

Assume that the high-pressure boilers use coal as fuel, and that coal costs $10.36 delivered to the plant. Assume also that the intermediate-pressure boilers use oil as fuel and that this oil costs $.061 per gallon delivered. Assume, further that the high-pressure boilers have an average generating rate of 10 lb of steam per pound of coal, and that the intermediate boilers have an average generating rate of 95 lb of steam per gallon of oil.

From these figures, the coal cost would be:

$$\frac{937{,}000{,}000}{10 \times 2000} \times \$10.36 = \$485{,}366,$$

and the oil cost would be:

$$\frac{219{,}900{,}000}{95} \times \$.061 = \$141{,}199$$

Total fuel cost would be $626,565.

Assume now that the plant purchased city water at a cost of $38,000, and 3,750,000 kw-hr of electric energy from the public utility at a cost of

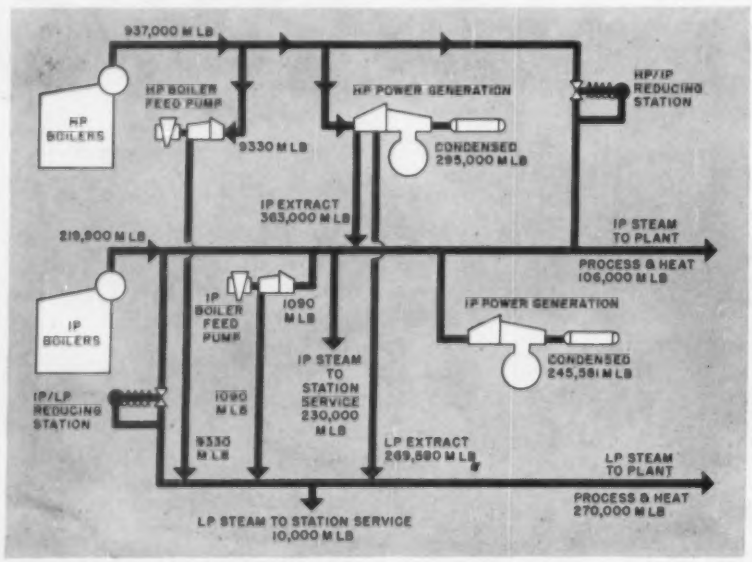

937,000 M LB
HP BOILERS
HP BOILER FEED PUMP
9330 M LB
HP POWER GENERATION
CONDENSED 295,000 M LB
HP/IP REDUCING STATION
IP EXTRACT 363,000 M LB
219,900 M LB
IP STEAM TO PLANT
PROCESS & HEAT 106,000 M LB
IP BOILERS
IP BOILER FEED PUMP
1090 M LB
IP POWER GENERATION
CONDENSED 245,581 M LB
IP STEAM TO STATION SERVICE 230,000 M LB
IP/LP REDUCING STATION
1090 M LB
5330 M LB
LP EXTRACT 269,590 M LB
LP STEAM TO PLANT
PROCESS & HEAT 270,000 M LB
LP STEAM TO STATION SERVICE 10,000 M LB

Fig. 1. Diagram showing distribution of process steam at various pressure levels

Table I—Budget of Operating Costs

Total operating cost, estimated, $1,519,935	
Operating labor, 10%	$ 151,990
Maintenance labor, 6%	91,200
Overhead, 15%	227,990
Supplies & materials, 6%	91,200
Fixed charges, 15%	227,900
Fuels, previously determined	626,565
Purchased utilities	103,000
Total Budgeted:	$1,519,935

Table II—Generating costs of the various utilities are here broken down to show how total cost of generation is allocated

Utility	1. Maintenance labor	2. Operating labor	3. Overhead	4. Materials & supplies	5. Fixed charges	6.* Station service	7. Total cost	8. Utility production	9. Unit cost
H.P. steam †	$47,600	$62,840	$98,740	$48,500	$55,250	$534,500	$847,430	937,000 M-lbs	$ .904 per M-lbs
I.P. steam	8,500	7,150	15,650	2,750	27,460	569,500	631,010	582,900 M-lbs	1.08 per M-lbs
L.P. steam	2,000	400	2,400	700	500	235,000	259,000	280,000 M-lbs	.925 per M-lbs
Electric power	7,600	21,600	29,200	12,000	55,600	680,000	806,000	46,000 M-kwh	.0175 per kwh
Compressed air	1,800	5,800	7,600	2,200	5,600	43,000	65,000	397,000 Mcf	.163 per Mcf
Treated water	6,700	26,900	33,600	22,100	19,000	3,300	111,600	941,000 M-gal	.119 per M-gal

* Includes fuel where applicable
† All H.P. steam used in power plant to produce other utilities

$65,000. Total cost of fuels and purchased utilities would be:

Fuel cost, coal	$485,366
oil	141,199
Purchased water	38,000
Purchased power	65,000
Total	$729,565

This sum would represent 48 per cent of the money spent to operate the utilities section, and therefore the answer to the first question asked would be:

$$\frac{\$729,565}{.48} = \$1,519,927 \text{ annually}$$

This total operating cost can be broken down to give a good, workable budget for a plant of this type and size in accordance with Table I. For budget purposes, money allocated for each purpose is rounded off to the nearest $10.

An answer to the second question concerning the recovery of cost can now be studied. The utilities engineer, knowing that there are certain charges which must be applied to each utility which he controls, is in a position to set up his charges in accordance with plant requirements and accounting practices.

It should be apparent that it is most necessary for the utilities engineer to obtain the closest coöperation from the plant accountant, so he can get all possible assistances in accumulating charges against the utilities section. It is also necessary to work closely with the timekeepers so labor charges can be correctly allocated.

Necessity for this close coöperation becomes more apparent as size of the plant increases and demand for utilities becomes greater and more varied.

Power labor costs are broken down into two primary classes: operating labor and maintenance labor. These two classes can each be further broken down as the necessity for more accurate computation of costs arises. The further breakdown is:

1. Operating labor
   a. utility generation
   b. utility distribution
2. Maintenance labor
   a. utility generation
   b. utility distribution

This breakdown will apply to each utility which is directly under the control of the power section:

A. Steam
   1. operating labor
      a. steam generation
      b. steam distribution
   2. maintenance labor
      a. steam generation
      b. steam distribution

or, if steam for the plant is required at more than one pressure level, then a similar labor charge breakdown could be made for each steam pressure which is furnished and distributed to the plant.

Table II shows how a breakdown of the dollar-costs of generating the first five of the utilities listed could very well work out.

Column 1 shows the labor which is charged directly to maintenance of the equipment directly involved in the generation of the utility in question.

Column 2 shows the labor which is charged directly to the operation of the equipment necessary to provide the various utilities.

Column 3 shows the overhead dollar-costs applied to each utility.

Column 4 shows the charge for supplies and materials used to operate and maintain equipment.

Column 5 shows fixed charges as applied only to the equipment used for generating the various utilities.

Column 6 shows the dollar-value of utilities used for station service to generate utilities distributed.

Column 7 gives the total cost of generation of each utility which is generated and distributed in the plant, including fuels.

Column 8 shows the amount of each utility consumed in the plant.

Column 9 gives the unit cost of generation of each of the utilities at the power plant.

Unit cost for the generation of each of the required utilities having been obtained, it now becomes necessary to determine the cost of distributing these services to each of the using sections.

Table III shows a breakdown of the costs of distributing utilities to the using sections, and is made up on the same basis as was Table I of the first article in this series. (Editor's note: see POWER ENGINEERING, April, 1959, for this table.) Charges made here are only those which can be applied to the systems which distribute the utilities to the various operating sections of the plant. These charges are also allocated against the distributed utilities only, not against the total.

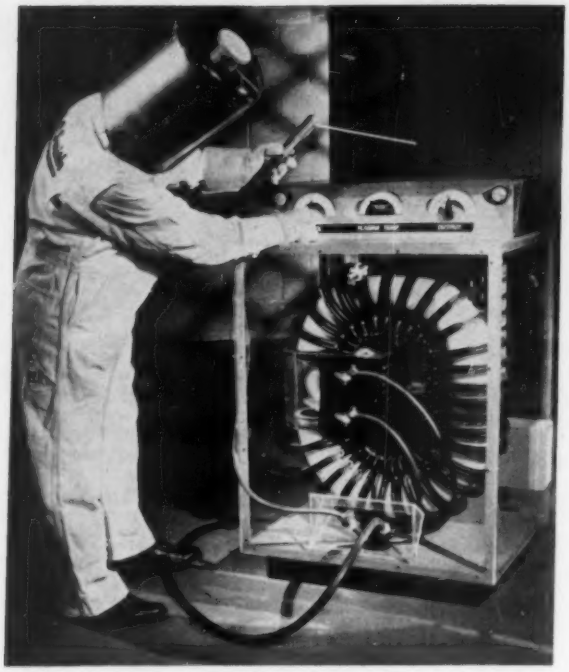
The author will continue his discussion of industrial power plant accounting practice in an early issue

Table III—Costs of distributing various utilities are broken down here to show how total distribution costs might be allocated

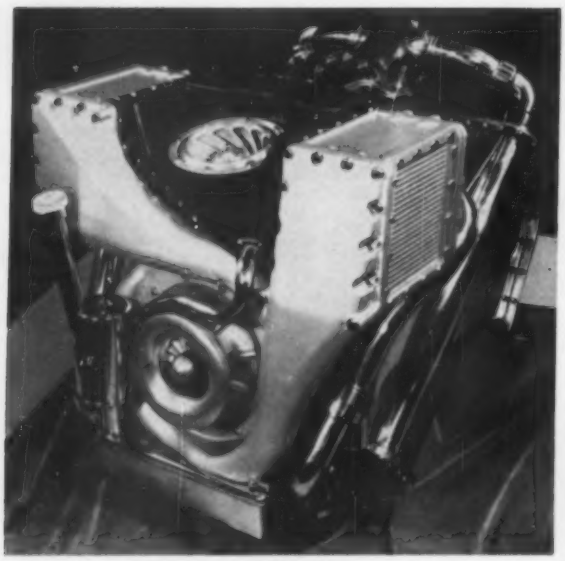
Utility	1. Maintenance labor	2. Operating labor	3. Overhead	4. Materials & supplies	5. Fixed charges	6. Station service	7. Total cost	8. Utility distribution	9. Unit cost
I.P. steam	$1,000	$ 500	$ 1,500	$200	$ 1,500	$——	$ 4,700	106,000 M-lbs	$.044 per M-lbs
L.P. steam	4,500	9,800	14,300	500	1,500	——	29,600	270,000 M-lbs	.109 per M-lbs
Electric power	3,300	4,500	7,800	750	33,000	——	49,350	34,400 M-kwh	.0014 per kwh
Compressed air	200	2,300	2,500	200	9,000	——	6,200	388,000 Mcf	.016 per Mcf
Treated water	600	6,300	6,900	300	9,200	15,000*	30,300	504,000 M-gal	.06 per M-gal.
Purchased water	2,400	3,400	5,800	500	2,200	68,000**	89,600	270,000 M-gal	.332 per M-gal
Purchased power	500	500	1,000	200	25,000	65,000***	92,200	3,750 M-kwh	.0247 per kwh

* Cost of internal power for pumping to distribution
** Includes cost of power for pumping and cost of water at meter
*** Cost of purchased power at meter

POWER ENGINEERING'S NEWS REEL

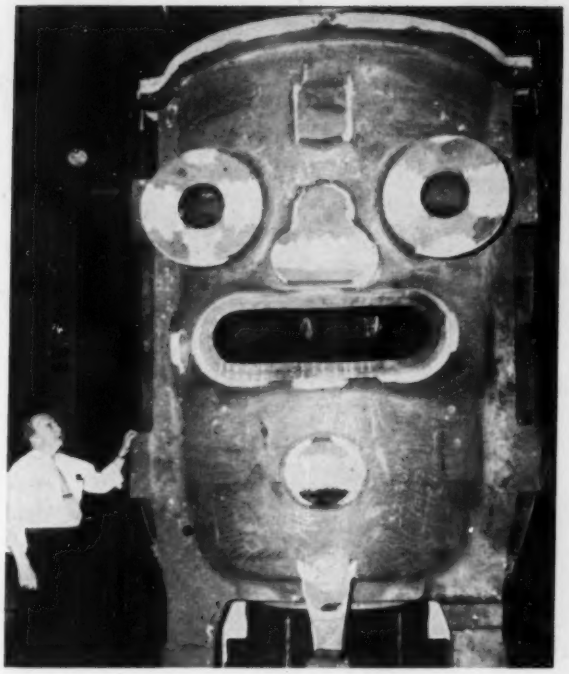


Fusion power welding is envisioned in this futuristic model called the Stellarweld and shown by A. O. Smith Corp at the American Welding Society Exposition. Using deuterium, the heavy isotope of hydrogen, as fuel, the Stellarweld could supply an estimated 20,000 kw, enough for 2500 arcs

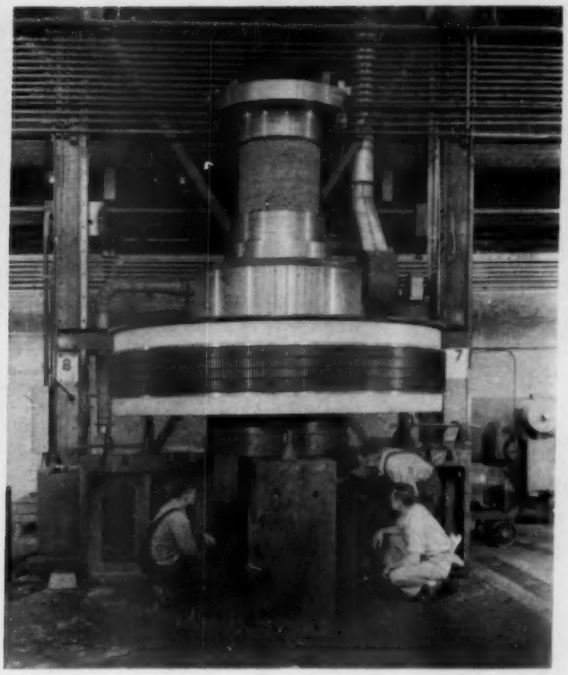


This is the "704," a supercharged gas turbine engine of 300 hp developed by Ford. It's 38 in. long, 29 wide and 28 high, weighs 650 lb installed, or about one-fourth as much as a truck diesel engine of comparable hp. The 704 has two stages of air compression, attains maximum fuel economy in a range of 25 to 100 per cent of power. Variety of fuels can be used. 704 will be tested in vehicles soon

Moving sidewalks make an appearance in San Diego, Cal. These moving platforms made by Otis Elevator arch 127 ft across a busy street and connect a hotel with a new motel and parking garage. Called "Travolators," these conveyors are also being used in the London Underground



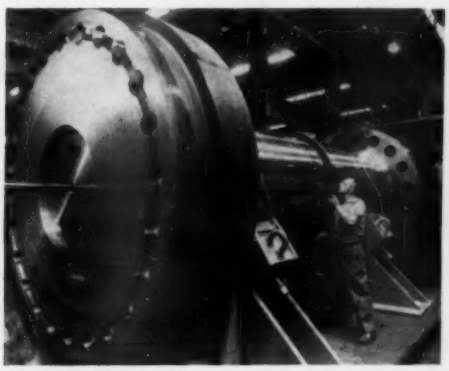
Giant iron mask is actually a portion of a steam turbine h-p shell. Mouth admits the initial h-p h-t steam into the turbine. Eye-like openings readmit reheated steam. Made by G-E, 30,000-lb shell is 18 ft high, is part of 82,500-kw turbine generator for new Palo Seco Station in Puerto Rico



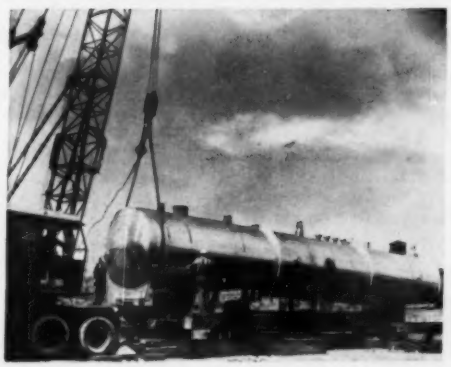
Princeton's Stellarator for experimenting with thermonuclear fusion will use record-size electrical components to provide power. This shaft for one of the generators, shown lowered into armature at Allis-Chalmers, is 130 in. long, has coupling diam of 53 in., weighs 32,000 lb

▲

Michigan's most powerful electric generating facility is now Detroit Edison's St. Clair Power Plant. New 320,000-kw generator has brought station's total capacity up to about 980,000 kw



First of thirteen 167,000-kva waterwheel generators for N. Y. State Authority's Niagara power project is nearing completion at Westinghouse. Part of it is the 50-ton shaft shown above on the 96-in. engine lathe. Its shank diam is 50 in.



Evaporator for ConEd's Indian Point nuclear power station arrives at Peekskill, N Y, from Griscom-Russell Co in Ohio. The 65-ft, 87,000-lb ▶ unit will produce 65,000 lb per hr of vapor at 62 psig Impurities will measure less than 0.25 ppm

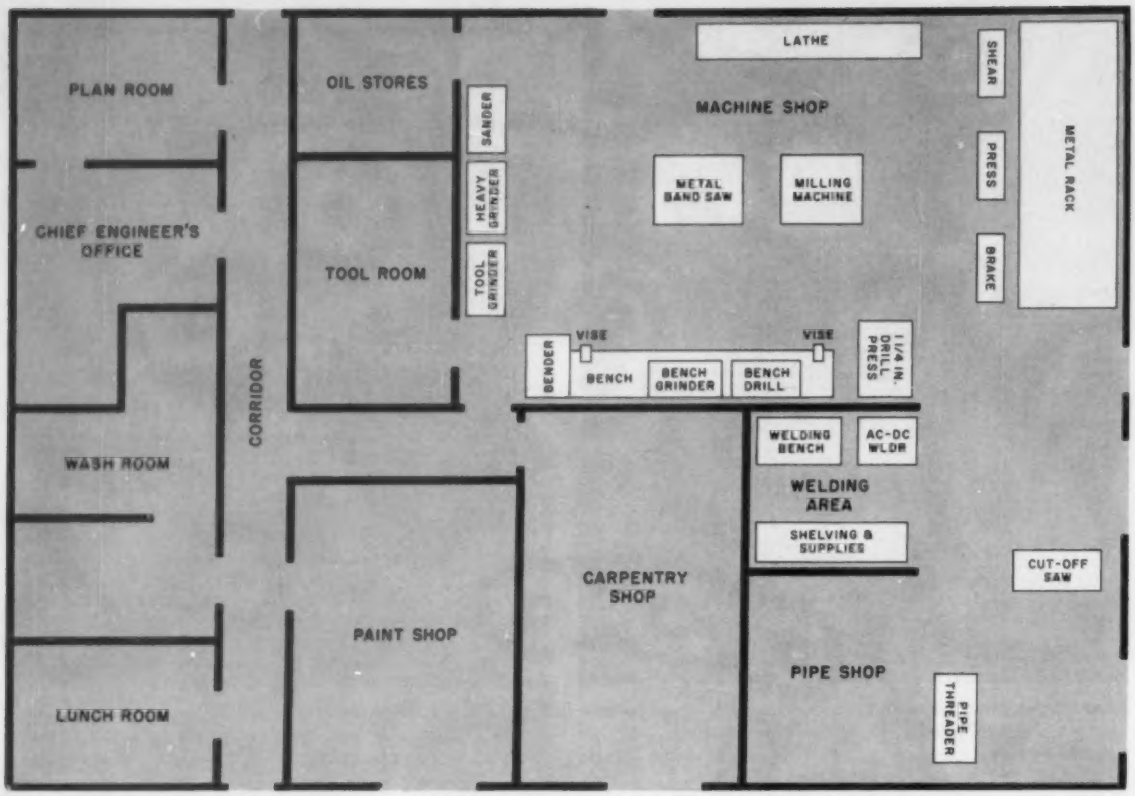


Fig. 1. Plan view of Carling's maintenance shops. Special features include outside loading doors for all shops, also lunchroom for craftsmen. Here the shops tie onto power plant building; also, architecture harmonizes with general design pattern

Tools for the Power Engineer

Properly equipped maintenance shops play an important role in the power field. Here's an excellent example—in Carling's new Atlanta Plant. Layouts, and tools, were selected after much research in the subject. Other typical shops will be described in future issues

By MEHL RENNER*

ATLANTA recently acquired one of the brewing industry's most modern plants. The pre-planning of the power facilities for this plant dictated a central-shop maintenance layout in the power plant. To best serve the needs of the entire brewery, an area of 3500 sq ft was dedicated to this function.

This brewing plant is a ten million dollar installation. Of the total cost, approximately 40 per cent is invested in buildings and grounds, and 60 per cent in mechanical and electrical facilities.

Power maintenance shops in this plant were designed for light maintenance and construction only, as the City of Atlanta is well endowed with heavy shops to handle the larger work. For shop tools and equipment, a budget of $40,000 was established when the plant was constructed.

Selection of layouts and equipment was based on experience at our other plants in Canada and the United States. Figure 1 shows a plan of the central shops, which includes the following:

Machine and metal-working shop
Welding shop
Pipefitting shop
Paint shop
Tool room

A maintenance parts and material storeroom was located in a separate building, as a matter of more efficient servicing.

Obviously, requirements and practices in such shop facilities vary widely, depending on the type of industry, its location, and size of the maintenance force. Ours is based on a force of 50 craftsmen for full plant production. This would be classed as a small to medium operation, so far as maintenance departments are concerned.

About eight months were spent in pre-planning of these shops. We selected the tools and equipment required, obtained bids, then made our selections. As proof that this planning paid off, we feel that a year of experience with the layout does not indicate any desired changes.

Shops are arranged so that bulky materials and equipment may be loaded directly into them through large steel doors. This avoids complicated handling problems. Other notable features are the Power Engineer's office, Plan Room, and a Lunch Room for the shop personnel.

As a possible help to other power engineers who are planning new shop facilities, we have listed the major tool and equipment items in each of the shops. (See opposite page.)

We feel that, for our particular operation, the facilities outlined herein are adequate and efficiently laid out to serve our needs.

*Production Manager, Carling Brewing Co, Atlanta, Georgia Plant

Fig. 2. Section of Machine Shop area, showing lathe, bench and accessory tools. Cleanliness is typical of all shops

Fig. 3. Exterior view of Maintenance Shops. Note attractive appearance and functional arrangement of outside doors

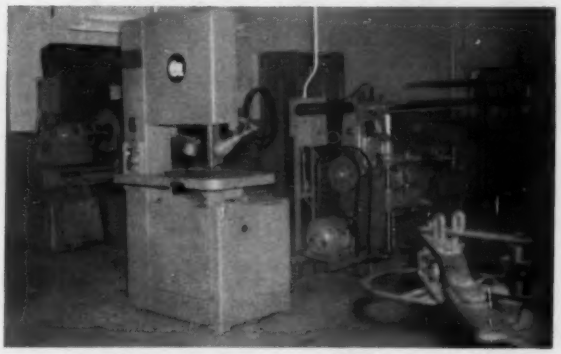


Fig. 4. Another view of Machine Shop. Note Metal Band Saw in foreground, and Pipe Racks in the right rear section

Fig. 5. Shown here are Brewmaster Ray Bleckaz (left) and Power Engineer Tom Power, both key men in the plant

MACHINE SHOP

1 — #60 South Bend Engine Lathe
1 — #24–10 Grobe Metal Band Saw
1 — #L-9 Metal Cut-off Saw
1 — 14 in. South Bend Drill Press
2 — ½hp Baldor Bench Grinders
1 — #648 Porter-Cable Belt Grinder
1 — Beverly Slitting Shear
1 — #2 Hossfeld Pipe Bender
1 — #21 Cincinnati Drill Press
1 — #412 Chicago Hand Brake
1 — #1652 Wysong Foot Shear
1 — #50H Drake Hydraulic Press
1 — #4F Queen City Grinder
3 — Work Benches
1 — Pipe and Metal Rack
2 — Bench Vises

CARPENTER SHOP

1 — 14 in. Delta Bench Drill Press
1 — 8 in. Delta Jointer
1 — 10 in. Tiltong Arbor Saw
1 — 20 in. Delta Band Saw
1 — 6 in. Delta Belt Sander
1 — 6½ in. Portable Skil Saw

PAINT SHOP

1 — Portable Compressor
Step Ladders (4 to 8 ft)
Complete Scaffolding for 24 ft Tower
Extension planks
1 — #29 Binks Spray Gun
Accessories for Spray Gun

WELDING SHOP

Oxy Acetylene Welding Outfit
1 — Lincoln 300 Amp Welder
1 — Lincoln 300 Amp Portable Welder
Soldering furnace and set of irons
Steel Welding Bench
Assorted Clamps, Blow Torch
1 — Prestolite Tank

ELECTRIC AND PIPE SHOP

1 — Electric Hammer
1 — Heavy Duty Grinder-Sander
1 — set Gear Pullers
1 — set Flaring Tools
1 — set Threading Equipment
1 — Portable Pipe Vise
1 — 1½ Ton Block and Chain
4 — Hydraulic Jacks
4 — Screw Jacks
Pipe Cutter
Bolt Cutter
Belt Splicer
Punch Set
1 — Threading Die Set
Complete set of drills, taps, reamers
1 — set Pipe Wrenches, 14 to 48 in.
1 — Complete Socket Wrench set
2 — Sledge Hammers
Complete set of Box and End Wrenches
Chain Pipe Tongs
Electric Marker
1 — Tugit Hoist
1 — Ammeter
1 — Volt Meter
1 — Megger Tester
1 — Battery-Powered Telephone set
1 — Set of Keyway Broaches
1 — Portable Sump Pump
1 — Sewer Cleaning Tape and Reel
6 — Electric Drills

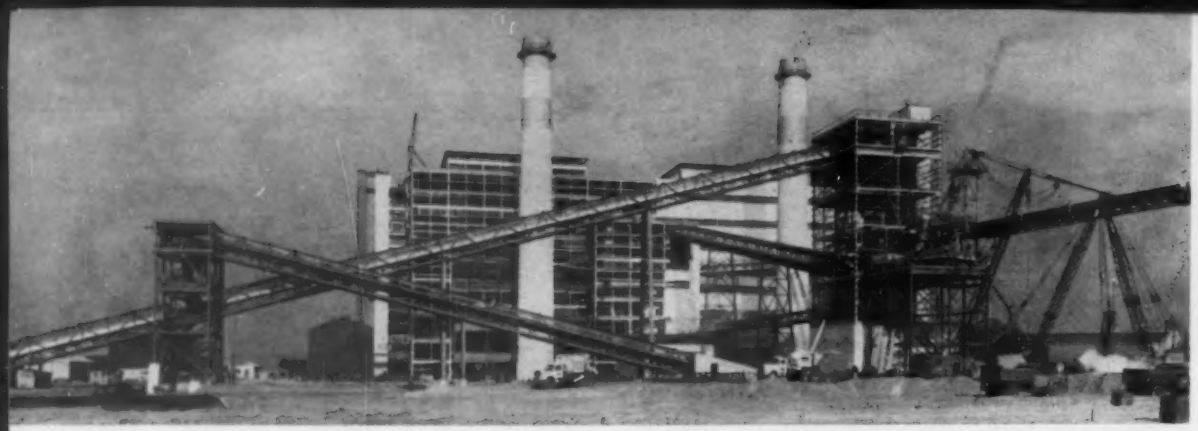
Editor's note: Due to the large number of reader requests for power shop information, we will present typical layouts and tool lists in coming months.

Construction of new facilities, and expansion in existing plants, creates a need for new power maintenance shops. Maintenance of power equipment becomes more important — and complicated — as new developments reach the field. This necessitates more tools, shops and test equipment, plus higher skills in the maintenance end of the business.

Power engineers have long recognized the wisdom of having adequate facilities for maintenance. Now, a new look at the tools and equipment in others' plants should be a good means of comparison for all who are in charge of maintenance operations in the power field. THE END

WOULD YOU LIKE TEAR SHEETS?

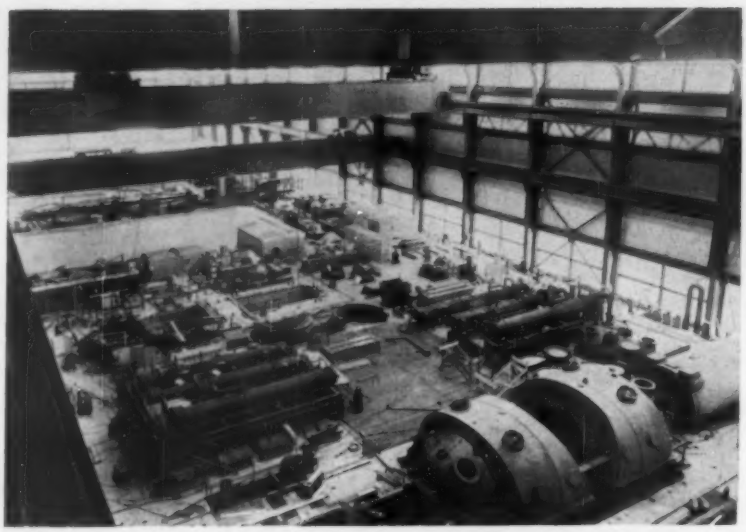
Readers who want tear sheets of any article appearing in the issue for their personal file may obtain them by indicating the item desired on one of the post cards appearing in this issue—Editors.



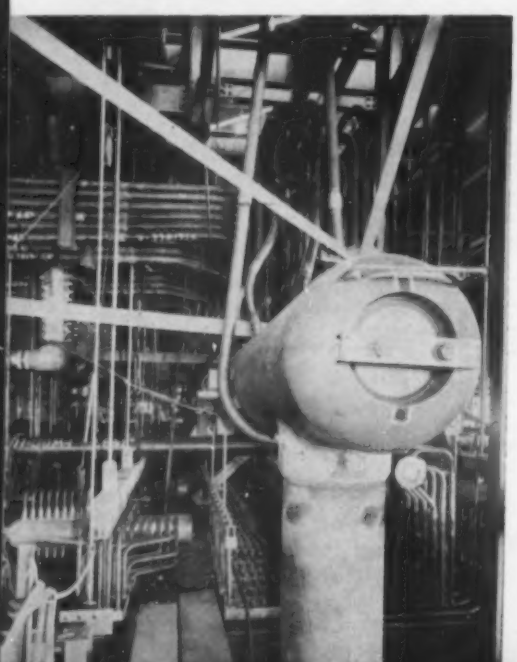
What Eddystone Station Looks Like During Construction

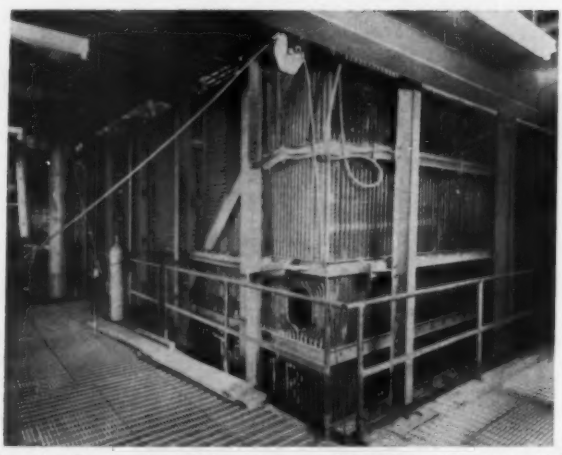
NEARLY ALL power engineers know what a large central generating station looks like in operation. This does not hold true for stations during construction, when a much more intimate view of what goes on behind panels and walls can be had.

Philadelphia Electric's Eddystone Station super-critical unit No. 1 is due for initial operation late in 1959. POWER ENGINEERING is proud to present here a picture story showing details of this unit that will not be visible again, while welding leads still tangle the premises, and before the final spit and polish is applied.



Turbine room operating floor, right, with generator and low-pressure elements of the cross-compound turbine in foreground. Foundations for high-pressure elements are just beyond horizontal high-pressure feed water heaters. Initial steam conditions for this Westinghouse unit will be 5000 psi at 1200 F with double reheat to 1050 F





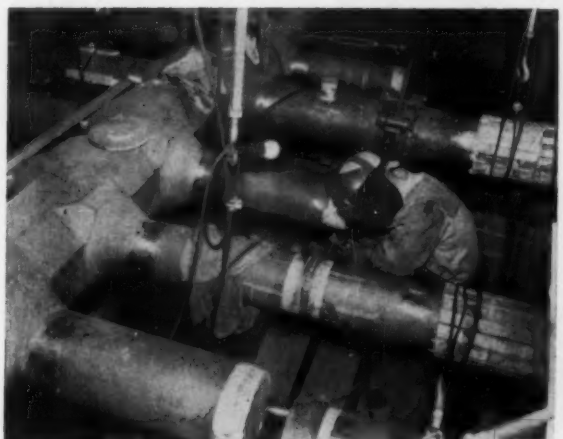
Boiler, by Combustion Engineering, is adaptation of the Swiss Sulzer once-through, forced-circulation design. Once-through boilers are not a new development, having been used extensively in Europe. At left is intermediate header for first reheat section, with vertical main steam outlet further to left. Furnace walls, shown above, were erected in panels which were prefabricated before raising to location

All controls for the station, including boiler, combustion, turbine generator, auxiliary power and outgoing transmission lines, will be gathered together in this air conditioned control room. This room has been designed to fill the requirements of two units. Boiler and combustion controls for the two million pound per hour unit are grouped on bench board, center in picture, turbine supervisory instruments and important temperature recorders are on near console at right. Mimic bus on panel at far end outlines electrical system

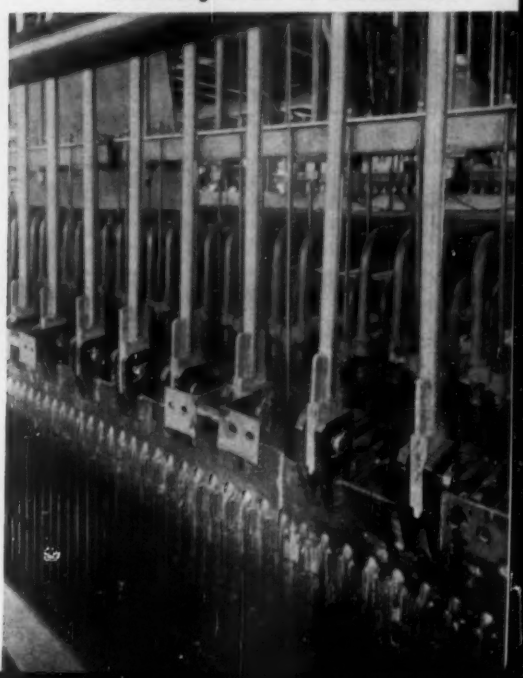
High-pressure boiler feed piping at the Sulzer control valves is shown at left. These are pressure-differential feedwater regulating valves and are located at operating floor level. Four independently controlled circuits are used from economizer inlet to outlet of transition section. Each system has been divided into two circuits, each with independent controls for water injection. Headers are provided at four intermediate points where flow through each circuit is thoroughly mixed. Combination of positive controls and mixing headers assures complete uniform temperature distribution from boiler

More on next page ▶

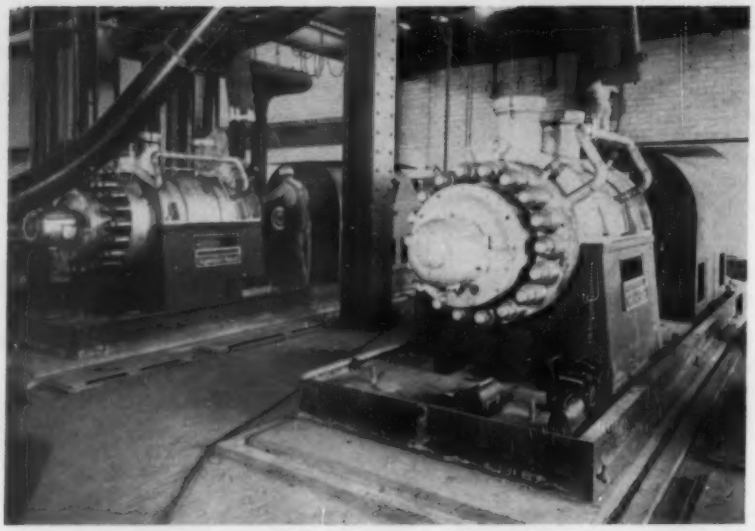
Boiler support follows standard practice of suspending units from overhead steel, as shown below, to eliminate expansion problems and simplify structure. Hangers are of stainless steel

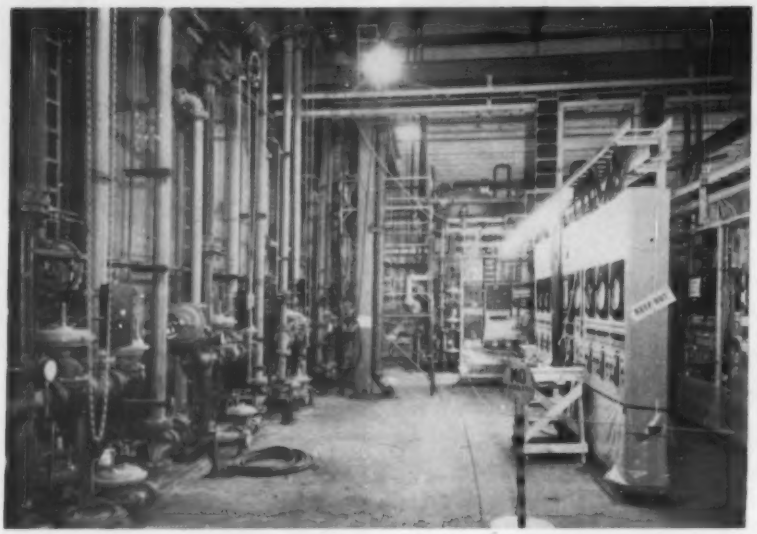


Main steam header, above, is fed by eight feeder pipes. The Combustion Engineering-Sulzer boiler employs eight parallel circuits through the superheater zones and is therefore equipped with eight stop valves. From each of these stop valves, a pipe leads to the mixing header, shown here, that serves to average any inequalities in steam temperature



Intermediate-pressure boiler feed pumps are shown at right. Feedwater pumping is done in three stages, with highest pressure feed heaters located between first and second pumps. Low and medium pressure pumps have motor drives. Highest pressure pump will be driven by a steam turbine. This turbine will take extraction steam from first cold reheat line of main unit and exhaust into the second cold reheat line. As load on main unit is increased, both inlet and exhaust pressures of the feed pump turbine will rise in proportion and maintain a constant ratio

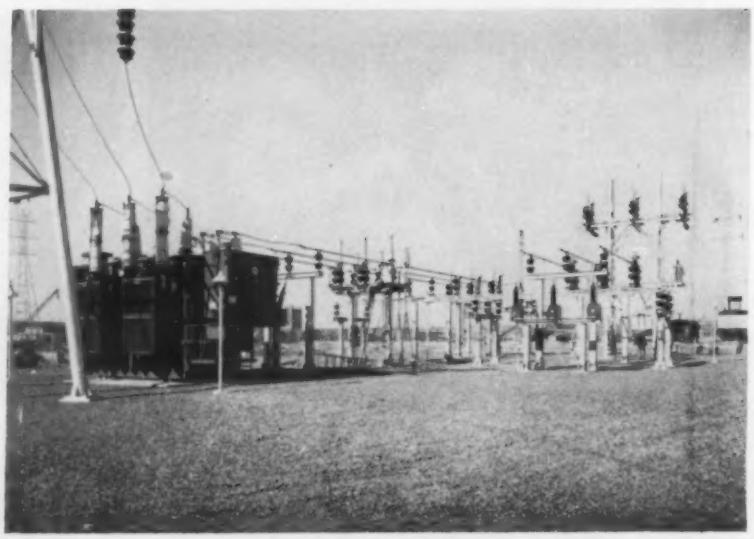




Water-treating facilities, controls for which are shown at left, will provide make-up water which has been purified so that total dissolved solids are less than 50 parts per billion. Water is passed through a two-bed demineralizer and then through a mixed-bed demineralizer. Condensate from the condenser will be passed through Solka-Floc filters, then a mixed-bed demineralizer to remove any solids that have been picked up in transit through boiler and feed water cycle

66-kv switchyard is shown at right. Both generators of the cross-compound set will aggregate 416,000 kva and will generate at 20,000 v. They will be solidly connected electrically to each other and to two 200,000-kva step-up transformers with an output potential of 132,000 v. Generators will also be connected to two auxiliary transformers rated at 12,000 kva each with output at 4000 v. One half of the station auxiliaries will be connected to one auxiliary power transformer, with remaining auxiliaries connected to the other. In addition, a starting transformer can provide emergency auxiliary power in event of trouble on either auxiliary transformer

THE END



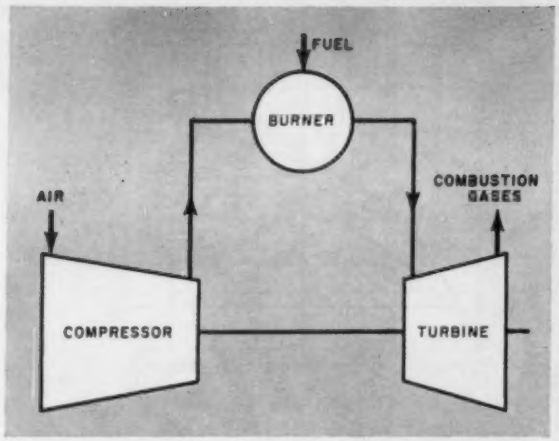


Fig. 1. Flow diagram for the simple open-cycle gas turbine

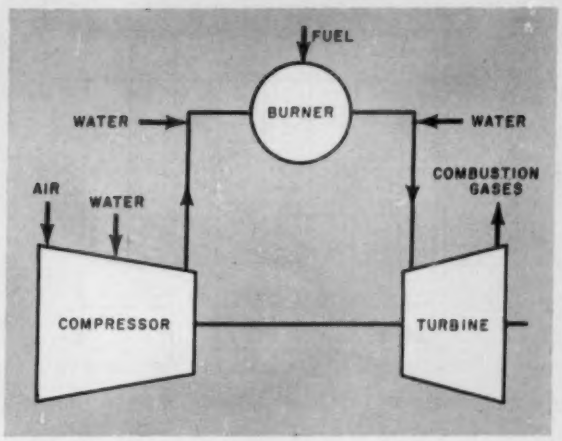


Fig. 2. Alternate provisions for water injection into cycle

Water or Steam Injection in Gas Turbine Cycle Provides Unique Performance

Greatly increased output, usually accompanied by lower efficiency and higher heat rate, results in much lower cost per kw installed

By JAY G. COUTANT*

SEVERAL FACTORS have brought the gas turbine rapid acceptance as a prime mover in a wide variety of jobs. In a few short years it has proved its high reliability and versatility, as well as its low installed cost, labor cost, standby and maintenance costs, low water requirements and low starting time.

Next important change in gas-turbine technology may well be the incorporation of water or steam injection, on both new and existing units. Quite startling results are being obtained through the use of this system, employing any of several different arrangements. This article discusses these arrangements and results.

Interest in this possibility is heightening, particularly in those applications where occasional overloads are required or desirable. One of the most obvious and interesting of these applications is in peaking service. Combined with such assets as ease of adapting to remote control and those attributes enumerated above, this low-cost-per-kw prime mover should indeed be a strong contender in this field in which so much interest is currently centered.

Most straightforward of all gas-turbine schemes is that shown in Fig. 1, a simple-cycle, single-shaft unit. Air is taken in through the compressor, heated in the combustion chamber, and discharged through the turbine. The turbine drives the compressor, and the difference between the work the turbine is able to do, and what is required to drive the compressor, is the net useful output of the machine.

Let us take a pound of air going into the compressor under typical conditions and see how much power comes out. Tabulating the data obtained from the Thermodynamic Properties of Air table, we find these values:

	Heat Content, Btu per lb
Air to compressor at 80 F.....	19.198
Air from compressor at 500 F...	121.275
Gas to turbine at 1450 F.....	370.320
Gas from turbine at 850 F.....	209.810

From these figures we see that the output of work from the turbine is 160.51 Btu per lb of air flow per sec, and the input to the compressor is 102.77 Btu per lb of air per sec. The difference, which is the actual output capability of the gas-turbine cycle, is 58.433 Btu, or 82.3 hp, per lb of air flow per sec.

Thus, if we have a design air flow of 260 lb of air per sec, we have a gas turbine which under design conditions will develop 260 times 82.3, or 21,398 hp, equivalent to 15,693 kw.

Efficiency

If the above values are at design efficiency, however, there are under all other conditions variations in efficiency which must be taken into account. These include losses (or gains) due to radiation, conduction, altitude, imperfect combustion, temperature, relative humidity, and variations from design pressures and velocities.

Reference to Fig. 4 will illustrate this point. Let us assume that the compression design point is six atmospheres. Under the specified conditions we see that the turbine cycle has a thermal efficiency of 25.6 per cent. Typical variations in efficiency are of these magnitudes: 1. Should the ambient air temperature rise from 59 F to 80 F, efficiency would decrease to 24.8 per cent; 2. Should the turbine be operating at 1000 ft elevation, efficiency would go down to 22.8 per cent; and, 3. Imperfect combustion might bring the efficiency down to 21 per cent.

It is apparent, therefore, that these variations are considerable, and must be taken into account in any gas-turbine calculations.

Injection

Under the above conditions, the table describes the effect of water and steam injection into the air stream before the combustor. It will be noted that the general effect on the cycle is to greatly increase the output, at a sizable decrease in efficiency, except when steam is used from an exhaust-heated waste-heat boiler.

Heat rate of the station, of course, varies inversely with the efficiency of the cycle.

An interesting aspect is the effect of injection on the cost of the unit per installed kw capacity. In peaking

* Assistant Secretary, Phoenix Iron & Steel Co

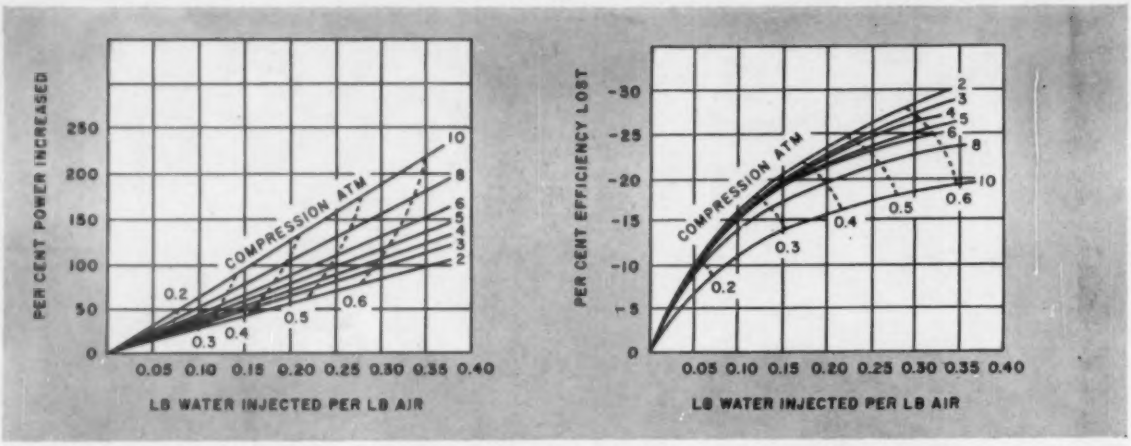


Fig. 3. Graphic analysis showing the effect of water injection on gas-turbine power output and thermal efficiency of cycle

service, this factor becomes extremely important and will in many cases decide the issue in favor of the gas turbine.

Figure 2 shows a system for the injection of water into the gas turbine cycle. Pure water (1 ppm or less solids) may be injected as a spray either immediately before or after the combustor, or both. This water is evaporated to form steam, thus using additional fuel, which accounts for the higher rate. More pounds of vapor, which may be considered as a gas, therefore flow through the turbine, enabling it to do more work, while the work done by the compressor is not increased correspondingly. Net capability is thus increased.

An alternative to this system calls for the water spray to be injected between stages of the compressor, thus cooling the air and lessening the work that must be done in compression. Since this lessening of work approximately offsets the decrease in efficiency resulting from evaporating the water, the thermal efficiency of the cycle is nearly the same as it is without injection. This system is in use in aircraft gas turbines.

Increase in output is dependent upon the amount of water injected. Fig. 3 shows this relation graphically. Conversely, the loss in efficiency becomes greater as the amount of water injected is increased, but this relationship is not as nearly linear as the first. Usual practice is to add water in the range of 0.1 lb per lb of air.

Where a gas turbine is installed for peaking in or near an existing steam plant, sufficiently-pure water for injection is usually available. In other cases, however, the installation may require expensive demineralizing equipment. This cost must of course be considered in evaluating the worth of water injection.

Another system, not requiring the high purity of water needed for injection, is that of allowing the hot air leaving the compressor to pass through an evaporator before entering the combustor. Investigation of this system has revealed that the gases will pick up up to five per cent of their weight, giving the corresponding increase in output. The gas is somewhat cooled, of course, thus giving the expected increase in heat rate.

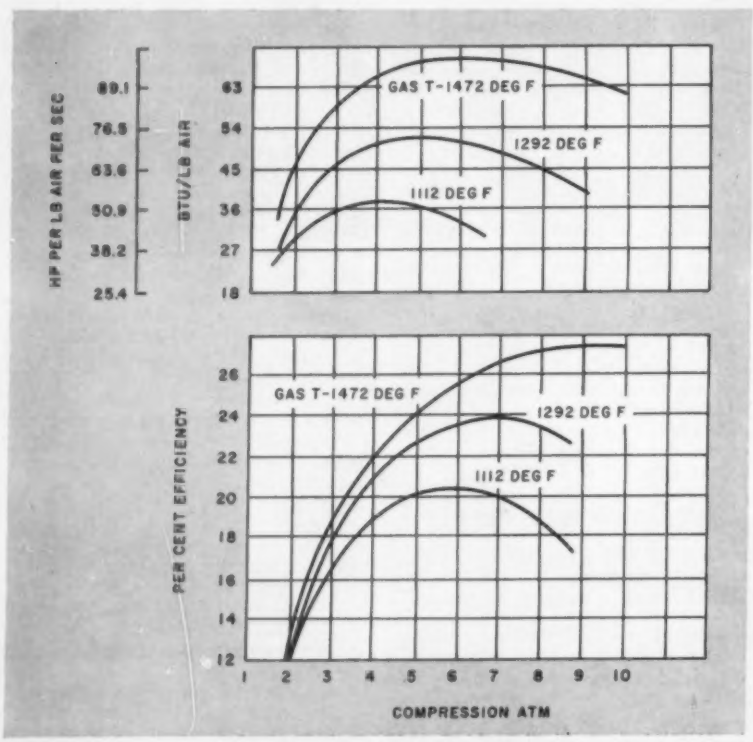


Fig. 4. Typical performance curves at various compression ratios and temperatures

Basic combustion conditions include: Air intake, 59 F; Humidity, 100 per cent; Atmospheric pressure, 29.92 in. of mercury; Air-to-hydrocarbon fuel ratio, 14 lb of air to 1 lb of oil; Turbine and compressor efficiencies, 85 per cent each

Steam Injection

Steam injection has different characteristics in several ways. Table I reveals that the increase in output is the same as that with water at the same weight ratio. Efficiency, heat rate, and price per installed kw capacity are likewise the same. There is a large increase in continuous rated capacity, however.

This is due to the fact that, while both operate at 17 per cent efficiency, and burn 23 per cent more fuel than the simple cycle, in steam injection this fuel is not burned in the combustor. Temperature of the gases, therefore, is not increased, except for

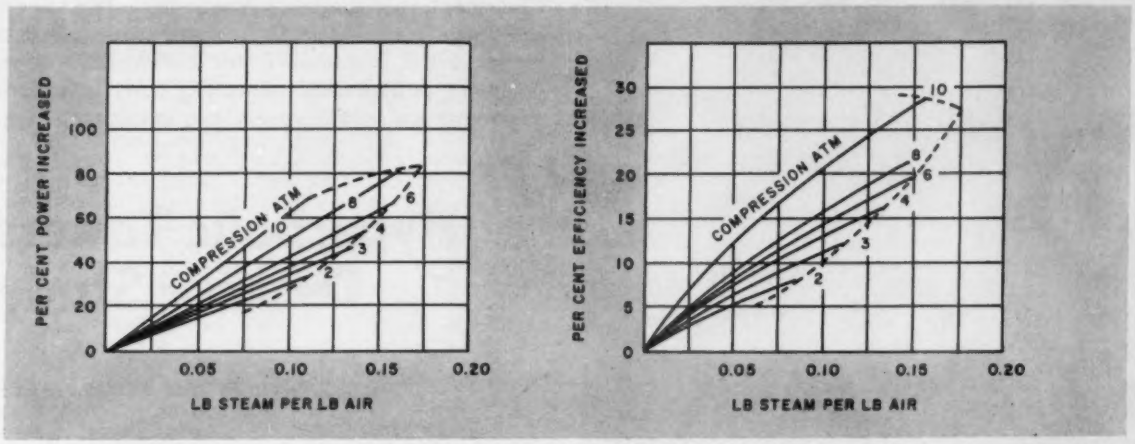


Fig. 5. Analysis comparable to Fig. 3, but for the injection of steam into the cycle. Efficiency in this case increases

a slight increase in the temperature of the exhaust gases due to the increased weight passing through. This has proved to be a minor factor, ever since the first tests were made as far back as 1920.

Water injection, on the other hand, burns the extra 23 per cent fuel in the combustion chamber — the combustor. This, according to *design*, may or may not raise the temperature of gases going into the turbine.

Limiting factors in gas-turbine design include the diameter of the rotor, and the strength of the material, which decreases with temperature and time. Rupture life is a third factor, and is determined by the creep of the metal, which results from centrifugal stresses and temperature gradients through the rotor, relative to the time of exposure.

Waste-Heat Boilers

In isolated stations, where steam is not available from a central steam system, it is necessary to install a waste-heat boiler, utilizing the heat in the exhaust gases to make the steam. Utilization of this heat raises the efficiency to a high level, and correspondingly lowers the heat rate. For these reasons, it may be economical to make such an installation even if other steam is available.

Use of a waste-heat boiler lowers the continuous rated capacity of the unit, because the pressure to which the turbine exhausts is necessarily raised a small amount. The same is true of the maximum overload capacity. This is due, of course, to whatever small resistance the waste-heat boiler will necessarily have to the passage of exhaust gases.

It is evident, then, from this summary of the effects of water and steam injection on gas-turbine operation, that such injection may well become a useful tool in the quest for maximum power at the lowest cost for a particular use. Where low installed cost per kw capacity is a governing factor, it is particularly applicable. THE END

Table shows comparison of results for various options of steam and water injection

Cycle	Overload Eff %	Overload Rate %	Continuous Rated Cap'y Kw	Overload Rate Cap'y Kw	Net Station Heat Rate Btu/Kwh	Approx Price Installed %
Simple Cycle No Overload	21	00	16,500	———	16,340	100
Water Injected Sprayed in Gas	17	39	16,500	23,000	20,040	76
Steam Injected by Fuel-Fired Boiler	17	39	22,100	23,000	20,040	76
Steam Injected by Waste-Heat Boiler	23.4	37.6	21,100	22,700	14,610	85

Includes Btu necessary for 200 psia saturated steam

RATING AT 80 F AND 1000 FT ELEVATION

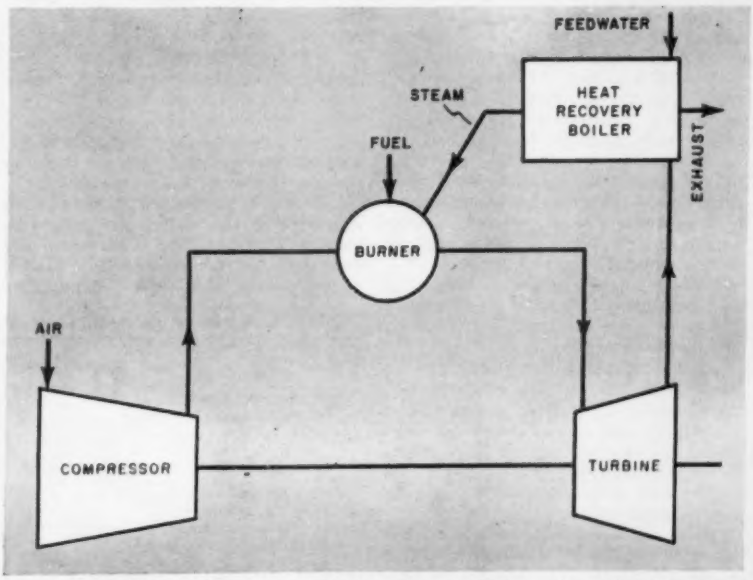


Fig. 6. Flow diagram for steam-injection system utilizing exhaust-heat recovery

Commonplace in Europe, hyperbolic cooling towers are largely untried in U. S. due to presupposed higher initial investment. The author says when complete capital and operating costs attendant to mechanical draft towers are considered . . .

Hyperbolic Towers Deserve Study

By J. F. VAN RYSSELBERGE *

Installation of hyperbolic cooling towers common to Europe. This photo shows the power station at Herserange, France

THERE IS NO NEED to describe the conventional induced draft type of wooden cooling towers. Such installations are fairly commonplace in the United States and are well known. On the other hand, a few words may be desirable to describe here the large natural-draft concrete cooling towers which, while they are not as yet well known in this country, are daily finding wider acceptance.

Natural-draft concrete cooling tower of the type under discussion is essentially a sort of chimney made out of a wall or veil of reinforced concrete built over and around a packing, or heat exchanger. The wall is 4 to 5 inches thick in the thinner portion of the tower. Outside air enters at the base of the tower below the packing and moves vertically through the packing.

Natural-draft towers of the general type under discussion have sometimes been built in the form of reinforced concrete cylinders of large diameter, over and above a wooden packing which the tower protects. Primarily to reduce the cost of construction, the cylindrical shape has evolved toward shapes generally referred to as hyperbolic in appearance. Such hyperbolic towers have also been erected by one world-wide organization over and above durable packings of asbestos cement. First of these was in use twenty years ago, and this form of construction has been used almost exclusively for the past few years in the larger towers.

Actual shape of the tower has no direct bearing on the efficiency of its operation. Friction losses within the upper part of the tower are negligible anyway, and shapes have sometimes adjusted to suit personal tastes of the user when construction methods allowed sufficient flexibility.

Ribs on the inner surface of the tower are optional, although a ribbed surface results in lower wind pressures as compared to a smooth surface. A ribbed surface therefore provides an added safety factor in a country where high winds prevail.

Inside of a concrete natural-draft cooling tower is, for the most part, empty space with the packing, or heat exchanger, occupying the lower 10 to 15 per cent of the tower height. Material consistently used in the Hamon cooling towers of the past few years has evolved from wood to a more permanent material: asbestos cement, in the form of sheets supported by prefabricated concrete columns and grids. Wood is still offered as a packing material and results in a lower-cost tower.

Less Maintenance with Concrete

General thinking, however, seems to be that for a tower of permanent material such as concrete, there will be a growing preference for a packing of long-lived material despite resulting higher cost of the tower. Under normal conditions, a tower with asbestos cement packing would require no shutdowns of generating units for inspection, maintenance, or replacement of packing in the tower.

Economic factors which we wish to compare in this article in regard to natural draft cooling towers and the conventional mechanical draft towers pertain to a 450,000-kw generating unit in the Illinois-Indiana-Ohio area. Characteristics of this installation are:

Water circulated:	230,000 gpm
Temp of water to tower	96.5 F
Temp of water from tower	80.5 F
Wet Bulb base temp	70.0 F
"Approach"	10.5 F

Our discussions are based on the first cost and on financial charges and operating expenses of the conventional tower that would fulfill these requirements. Conclusions are derived therefrom to evaluate magnitude of the maximum investment, theoretically justifiable, in a natural-draft installation that would result for an electric utility in annual charges and expenses equal to the conventional installation. Therefore, a discussion is offered with regard to true construction cost of the natural-draft alternative, as ascertained from reliable American contractors.

For simplification, pumping heads for the conventional and the natural-draft towers are the same, thus eliminating consideration of the circulating water pumps and their power consumption. In connection with the hot water piping to the tower site and the cold water canals from the tower site, weight has been given the fact that the conventional tower would be located some 500 ft beyond the natural-draft installation.

Prices for conventional installa-

Table I. Comparison of mechanical and natural draft towers for 450-mw unit

Characteristic	Mechanical Draft	Natural Draft
Number of towers	4	2
Length per tower	280 ft	
Width per tower	67 ft	
Height	54 ft incl. fan cyl.	361 ft
No. cells per tower	10	
Pumping head	35 ft	35 ft
Basin area per tower	18,750 sq ft	60,000 sq ft
Fan power per tower	620 hp	nil
Total area occupied by complete installation	500,000 to 700,000 sq ft	300,000 to 350,000 sq ft

* Consulting engineer, Hamon, Inc.

tions are composed of two groups of elements: A. cooling towers as delivered and erected by the manufacturer and, B. all other related costs paid by the purchaser such as basins, fan motors, transformers, controls, anchor bolts, piping, and canals from the main valves at the tower site to and from the individual towers. To this has been added the 500 ft differential mentioned above.

The conventional tower installation answering the imposed requirements with maximum operating reliability requires high cylinders, relatively wide tower spacing, wood impregnation, control equipment and the like in order to approach the reliability of natural draft. Elements of price for such mechanical draft towers are, in round figures:

Cooling towers, delivered and erected	$1,520,000
Added related expense	1,280,000
Total cost of towers	$2,800,000

General characteristics of this conventional installation are shown in the first column of Table I. Characteristics of the Hamon natural-draft concrete cooling tower installation to meet the same imposed cooling requirements are shown in the second column of the same table.

We should not attempt to evaluate the maximum price that a utility company could in theory pay for such a natural-draft installation without trying to give weight to a series of important advantages of the concrete towers over the wooden towers that are sometimes intangible and hard to evaluate.

Such advantages, among others, are: no recirculation, no ground fogging, no frozen spray, no efficiency or capacity loss due to mechanical outages or deteriorated wood packing, no fire hazard, resistance to high winds and earthquakes, and smaller over-all area needed for locating the towers.

Maximum price that a utility company can afford to pay for a natural draft installation depends on the total of the fixed charges and operating expenses that accrue to the alternate conventional induced-draft installation. As shown in greater detail in Table II, total of these annual charges and expenses is evaluated at $676,500 per year for the case under study. This figure includes the cost of electric power required to operate the fans, which amounts to $103,500 per year.

Advantages of Natural Draft

With the natural-draft concrete tower installation, there are no fans required and maintenance cost would be nil if the packing were of asbestos-cement. Thus, for the natural draft installation, the $676,500 would represent its fixed charges only.

Considering the fact that permanent materials are involved in the natural-draft tower with useful lives of, say, 40 years for the concrete and an assumed 25 years (probably considerably more in practice) for the asbestos cement filling, a capitalization rate of 15 per cent is applied to the $676,500 annual charges. This results in a theoretically justifiable investment in natural-draft equipment of $4,500,000, or 1.6 times the $2,800,000 original investment in mechanical draft equipment. Let it be repeated that the figure of $4,500,000 does not reflect a series of advantages, some of them intangible, that concrete towers have over wood towers.

For the same 450,000-kw installation, studies made for "approaches" of 12 and 16 deg respectively, and with all other conditions remaining equal or comparable, lead to the conclusion that the theoretically justifiable investment in natural-draft equipment is $3,959,000 and $3,110,000 respectively. These figures represent some 1.7 times the total original investment in corresponding mechanical draft installations.

All indications from careful and lengthy studies made with American contractors, and allowing for adaptation to this country of construction methods used abroad for the erection of concrete towers, show that the cost of the natural-draft concrete tower installation delivered to the customer will not be in the order of 1.6 to 1.7 times the investment in mechanical draft equipment, but more nearly 1.25 times that investment.

There seems to be a prevailing opinion in the country that investment in natural draft is in some cases as high as 2.5 times that for mechanical-draft equipment. This ratio, for the cases here studied, can only be obtained if mechanical draft towers are considered without their heavy associated investments, which is an incomplete and erroneous comparison. As explained, the correct ratio is more nearly 1.25, and natural draft would remain economically advantageous even if this ratio should grow to 1.6 or 1.7 times the mechanical-draft investment, besides presenting numerous intangible benefits over mechanical draft. THE END

Want more information?

If you would like to know more about this interesting subject, write the editors or simply jot "hyperbolic cooling towers" on one of the reader service cards in the back of this issue.

Table II. This tabulation shows proper method of making financial study of new tower with all factors being considered

A. Annual Costs Associated With Conventional Tower		B. Annual Costs of Electric Energy For Fans	
1. Investment in installation	$2,800,000	1. Fan power required, expressed in hp	2,480
2. Yearly gross return desired	12%	Fan power required, expressed in kw	1,840
3. Overall composite annual depreciation	4.8%	2. Power plant capacity for fans, kw	2,100
4. Overall composite annual insurance	0.7%	3. Hours use per year (92% load factor), hrs	8,000
5. Total annual rate of fixed charges	17.5%	4. Kwh consumed per year by fans	16,800,000
6. Annual fixed charges	$ 490,000	5. Cost per installed kw of plant	$ 150
7. Annual minimum maintenance *	$ 64,000	6. Fixed charge rate applicable to 5	15.5%
8. Total annual charges and maintenance on conventional tower installation	$ 554,000	7. Cost per kwh of energy, mills	3.25
		8. Annual cost of power for fans: Fixed charges: 2100 kw x $150 x 15.5% = $48,800 Energy cost: 16,800,000 kw x 3.25 mills = $54,700	
		9. Total cost of power for fans	$ 103,500
C. Total annual cost of conventional tower installation, including electricity for fans			$657,500
D. For increased plant heat rate over the year resulting from use of mechanical draft as compared to natural draft **			$ 19,000
E. C plus D — total annual cost of conventional tower installation, including electricity for fans, plus heat rate increase resulting from use of mechanical draft			$676,500

* Taken at about 4% of cost of tower erected, including fan motors but exclusive of basin, electric wiring or riser piping. In ASME paper 56-A59 by M. W. Larinoff of Ebasco Services, maintenance costs are shown to increase sharply at exponential rate with age of tower: on 8-yr-old tower maintenance averages 4.6%; on 15-yr-old tower, 6.6%. The 4% figure is believed fair under present conditions.

** Because of greater draft with lower wet-bulb temperatures and higher humidities. Natural draft gives cooler circulating water temperatures than mechanical draft in the cooler seasons, thus an efficiency benefit to credit of natural draft and a liability to mechanical draft. Considering seasonal temperature variations, the corresponding changes in efficiency can be evaluated between the two types of installations for an approximate unit loading and an approximate fuel cost.

How Many Volts to Kill You?

Problem of electric shock, its exact nature and treatment, is still fraught with a measure of mystery. But everyone working with electricity should know these fundamentals about the hazard

BY DR. W. SCHWEISHEIMER

MACHINIST was electrocuted by touching a wire of 2300 volts. This tragic occurrence raised the question, How much electricity is necessary to electrocute a person, and how long must the electricity be applied?

According to the *Journal of the American Medical Association*, the intensity of current was less than 110 ma in two recent cases of fatal shock. Some authorities say currents as low as 25 ma have been fatal. In other cases, however, currents of many amperes have failed to cause death, although they produced severe local burns in the extremities.

Why the inconsistency in this matter of current? It results from the different paths taken by the current through the body. Actually, the heart is the most vulnerable organ; and interestingly enough, within each movement of the heart there is a period during which the heart is less susceptible to shock than it is at other times. For this reason, the exact instant of the shock is often all-important in deciding the outcome.

Duration of flow can be less than one millisecond, the *Journal* says. Since the body as a whole is a conductor, it becomes part of a condenser whenever it is separated by a dielectric from any other conductor. The thinner the dielectric and the greater the opposed areas of the two conductors, the greater the capacity of the condenser so formed. Under favorable conditions, the capacity of this condenser would reach one millimicro farad.

Charged at 1000 volts, it could deliver 0.000001 coulombs which would maintain a current of 1 ma for 0.001 sec. Under certain special conditions, this quantity could be still further increased and might even give a perceptible shock to another person.

Low-Voltage Hazard

Although the danger of high voltage is generally known, there is ever need to be careful of low voltage as well. Low voltages are dangerous because they interfere with the mechanism of the heart muscle and produce what is called ventricular fibrillation (disturbances of the muscular activity of the heart ventricle).

Most industrial electrical hazards are in the lower voltage range (120 to 440 volts). Dr. W. B. Kouwenhower, professor of electrical engineering at Johns Hopkins University, has stated: "There are a number of cases on record where contact with 60- and 65-v circuits of commercial frequencies have resulted in fatal accidents." Lowest voltage facility of which he has any record occurred at 46 volts, 60 cycles. It seems probable that circuits of 24 volts or less may be considered as safe under practically all conditions.

Low-voltage current is hazardous particularly when the body contacting it is wet from perspiration, a bath, or drenching rain. The body must also be in close contact with both the ground and the live conductor.

High-Voltage Hazard

In the case of high voltages, most contacts result in serious injury. In the range of from 1000 to 7500 volts, almost every contact which causes current to flow across the body will cause a non-breathing shock condition. About half of these can be revived if artificial respiration is started promptly.

Circuits of more than 7500 volts need not be contacted to produce severe injury since the electric current is able to jump a gap in this volt range.

Recently, high-voltage accidents have been described where men came in contact with conductors carrying 45,000 to 50,000 volts. In most cases, artificial respiration had to be carried out for a long time, and some of the men actually recovered. Change within the muscles due to the high-voltage current produced lasting damage to the kidneys, which had to excrete the destroyed muscle.

The two immediate problems of treatment of electric shock are: 1. the suspended respiration, and 2. the fibrillation of the heart muscle. Both are urgent. If the heart is not fibrillating (i.e., if the regularity of the action of the heart muscle is out of order), artificial respiration must be started at once.

On the other hand, if the heart muscle is fibrillating, the doctor has a choice of various treatments (none of which is absolutely reliable). Generally, it is safe to say that if the patient survived the electric shock at all, no specific treatment is indicated. Damage from electric shock is ordinarily either of a temporary nature or it is fatal. Only rarely will an electric shock cause permanent damage.

Degree of shock produced by an electric current is influenced by length of contact, strength of current, parts of the body through which the current passes, and some other factors.

Report from Great Britain describes more than 100 successful attempts to revive men after an electric shock severe enough to produce unconsciousness. Dr. Jellinek, a well-known authority on electrical accidents, mentions 12 cases in his latest book. Longest interval between shock and returning consciousness was 90 minutes.

Dr. Jellinek stresses that in cases of apparent death after electric shock the heart activity may be so low and slow that it cannot be heard or discovered. He insists that artificial respiration should be continued for a number of hours. It is advisable to continue artificial respiration after electric shock for two hours after all signs of life have ceased.

Dr. Jellinek points out that our present theoretic knowledge of the peculiarities of electric shock and electric injuries asks for an entirely conservative method of treatment. Two measures may prove necessary: lumbar puncture (tapping of the spine for relief of pressure or for diagnostic reasons), and stanching of sudden unexpected bleeding.

Again, the nervous system may be so profoundly shocked or fatigued by contact with electric current that it cannot function normally for a period of minutes or hours. The victim, though conscious, is temporarily paralyzed. If nature is given the opportunity, she will often repair the temporary damage and again permit the signals from the brain to reach the organ or limb which was temporarily paralyzed by the shock.

Precautions

Precautions to take against electric shock:

Cover all ground with rubber blankets or mats. Cover every live line within reach with a line hose. If working on live lines of less than 4000 volts, wear rubber gloves and sleeves with protectors. Never permit a live line connection to dangle loosely.

Rubber gloves should be tested and rotated at least monthly. For live work about 4000 volts, hot-line tools should be used. Nobody should depend upon two pairs of rubber gloves, worn one over the other; this is not sufficient protection for high-voltage current.

It is a well-known fact that nearly half of all the deaths from accidental electric shock occur in the three summer months. Greater outdoor industrial activity and frequent perspiration in the warm months are two of the causes, but they do not give complete explanation. As in all problems connected with electric shock, there is still a measure of mystery connected with the increased hazard of electric shock in summer time. THE END

What Is an American Standard?

American Standards for transformers, regulators, reactors, switchgear, insulated wire, and many other equipments are of major importance to the power engineer. Yet few probably are aware of how such Standards are created. This account of ASA tells how it's done

By S. DAVID HOFFMAN

HOW is an American Standard made?

Let's look first at an event which took place recently in a plain, old-fashioned room in the Grand Central Terminal Office Building in New York City.

In that room, in the offices of the American Standards Association, 30 men had come together from associations, societies and industries all of which had one interest in common — electrical engineering. These 30 conferees represented, among others, the American Institute of Electrical Engineers, National Electrical Manufacturers Association, American Society for Testing Materials, National Bureau of Standards, the electric light and power industries, Rural Electrification Administration, telephone industry, and the Tennessee Valley Authority.

What these 30 men discussed did not make news in the daily press. Yet the work they began on that day may eventually bear valuable economic and technical fruit for the power industry.

At the end of the meeting, the conference passed unanimously a resolution to the effect that a committee be formed under the procedures of the American Standards Association, to study the coördination of insulation strengths of the different types of apparatus used in electrical systems, and to develop coördinated minimum values for the external dielectric requirements of outdoor apparatus for power transmission and distribution. The committee's scope would also include coördination of its work with other American standards and with international standards in this field.

The American Standards Association reviewed the group's resolution, to make sure that it represented a consensus of all national groups substantially concerned with the scope of the project. Satisfied that such a consensus existed, ASA subsequently authorized the formation of the proposed committee, calling it Sectional Committee C92, and this Committee is even now being formed under the joint sponsorship of AIEE and NEMA.

DAVID HOFFMAN became head of ASA's electrical engineering department in 1954, and is in charge of the standards program for acoustics, electrical and electronic fields. He is a graduate of Yale University, where he won the B.E. (E.E.) degree in 1945. He also holds an LL.B. degree, from St. John's University

How Approval Is Won

According to ASA rules, membership in a sectional committee has to be truly representative of all national groups substantially concerned with its work. When, eventually, Sectional Committee C92 formulates one or several standards and submits a standard to ASA for approval as an American Standard, ASA will again make sure that the standard is supported by the consensus of all national groups substantially concerned with the scope and provisions of the standard. Only then will ASA approve the standard as an American Standard.

This procedure, out of which the newly formed Sectional Committee C92 was created, is basically the one that has been followed for many of the more than 400 American Standards in the field of electrical engineering now in existence. The majority of these American Standards are of importance to the power engineer — among them American Standards for transformers, regulators, and reactors; for power switchgear and control gear; for rotating machinery; for electrical insulation materials; for bare wire, insulated wire, and magnet wire; for electrical measuring instruments; and for definitions of electrical terms. The well-known National Electric Code and the Residential Wiring Handbook also are American Standards.

Why is there the need to make a standard an American Standard? Why would it not suffice to have an electrical standard approved by one of the organizations specializing in electrical engineering — and would it not also be simpler than to go through the procedures of the American Standards Association?

Answer is this: electrical material and equipment are used by many other industries — in fact, by practically every industry in the country. Thus, an electrical standard must not only satisfy the manufacturer but also a score of different user industries. Moreover, many electrical standards, and especially those involving safety considerations, must be acceptable to government authorities at all levels. Otherwise, each local community might write its own electrical code requirements, and there would be almost as many different codes as there are communities. Manufacturers of electrical equipment would then have to make hundreds or thousands of different types of the same piece of equipment. The additional cost to the economy would be fantastic, and sales of the electrical industry would probably be only a fraction of what they are now.

To obtain a standard acceptable to all national groups concerned with it, a neutral agency is needed that is not identified with any one industry, profession, or economic or political interest. For this very purpose, the forerunner of the present American Standards Association was founded in 1918 by the five leading engineering societies of the country, among them the AIEE. ASA was reorganized in 1928, when it assumed essentially its present form.

Today, ASA is a federation of 119 professional societies and trade associations. It has more than 2000 company members. More than 1700 American Standards have been approved. About 400 standards projects are being actively pursued at present under the procedures of ASA, with the participation of about 10,000 engineers, government officials, and experts from industry and other national groups.

ASA does not write standards. It provides the procedures, the rules, and the judicial and administrative services for the approval of American Standards. The actual work of formulating the standards is performed by the experts representing the various national groups interested in the standard. ASA approves a standard as an American Standard only if it is accepted by a consensus of all national groups substantially concerned with the standard.

This consensus principle is the basis of all ASA procedures. However, a consensus does not necessarily mean a unanimous vote. Votes are weighed as well as counted. A weighty objection of an important organization may outweigh all other affirmative votes.

On the other hand, a number of negative votes of groups that are only distantly concerned with the subject matter may be discounted in the face of affirmative votes of groups that are vitally affected by a standards project.

Under the sectional committee method of ASA, the actual work of developing and formulating an American Standard is carried on under ASA procedures. However, there also are two other methods of obtaining an American Standard.

Existing Standards Method

One is the existing standards method, under which the already existing standard of an organization may be submitted to ASA for approval as an American Standard. Approval as an American Standard is based on the same principles that apply to standards developed by an ASA sectional committee. Many of the standards of the American Society for Testing Materials are approved as American Standards under the existing standards method.

Secondly, there is the general acceptance method, under which a simple standard can be accepted at a general conference attended by all interested groups. This was the case, for instance, with the industrial inch-millimeter conversion factor of 1 inch = 25.4 millimeters, approved as an American Standard in 1933.

Thousands of standards are in existence which have not been approved as American Standards. These include standards produced by trade associations, technical societies and professional groups. National organizations which are concerned with standardization in fields related to the interests of power engineers are National Electrical Manufacturers Assn, American Institute of Electrical Engineers, American Society for Testing Materials, Electronic Industries Assn, National Board of Fire Underwriters, and others.

All of the above-named are in the ASA federation and are active in the national standards program conducted through ASA. The fact that many of their standards have not been submitted to ASA for approval as American Standards does not mean that the purely association or society standards do not have industry recognition. Power engineers should avail themselves of standards literature issued by these and other organizations.

International Aspects

Among ASA's other important functions is the representation of American interests in international standards work. Of particular interest to the power industry is the work done by the International Electrotechnical Commission (IEC). IEC was founded in 1904 for the development of international standards in the electrotechnical and related fields. American delegates to IEC meetings are accredited by the U. S. National Committee for IEC, an arm of the American Standards Association.

National committees of 38 nations are members of IEC. More than 80 technical committees and subcommittees are active at present on international standards for the electrical and kindred industries. The U. S. participates in the work of all but five of these.

About 100 recommended IEC standards are presently published. Many of these are of interest to power engineers, such as IEC Publication 76 — Recommendations for Power Transformers; and IEC Publication 56 — Specifications for Alternating Current Circuit Breakers. (All IEC publications, as well as American Standards, can be purchased from ASA. Price lists of these are available from ASA, at 70 E. 45th St., New York 17, N. Y.) The American electrical industry has always been active in IEC work, in recognition of the fact that world standards are vital to develop world markets.

Impartiality

To preserve its reputation for complete impartiality — be it in the approval of an American Standard or in the representation on international standards committees — ASA makes its services available to members and non-members alike. Any organization with a legitimate interest in a standards project can use ASA's services.

This public service principle often poses financial problems. ASA relies for its operating funds entirely on membership fees, other voluntary contributions, and the sale of published standards. There is no financial support from the federal government or any other government agency.

While it is difficult to weigh the direct costs of ASA services to any one industry against that industry's direct support, there is no doubt in the minds of ASA directors that some industries get more direct services than they pay for. Measured in indirect benefits from American Standards — such as reduced production costs and larger markets — all industries using American Standards reap dividends that are a multiple of their investments. THE END

Survey Shows Comparative Prices for Fuel in 1958

BITUMINOUS COAL INSTITUTE has surveyed 276 cities, in search for comparative fuel prices as they stood in 1958. Survey covered all major industrial areas where solid and fluid fuels are in competition.

Gas costs are substantially higher than coal costs in 88 per cent of 234 cities where both are still available. Oil prices are still higher than coal prices in 69 per cent of 175 cities showing coal-oil competition.

The tabulation shows the 1958 fuel cost comparison in 10 of the 18 major industrial areas (100,000 or more manufacturing employes) where off-track coal is sold.

Survey showed that the off-track coal market contracted most where fuel cost comparisons were unfavorable to coal. In a two-way comparison, the same fate overtook oil where prices were substantially higher than those of gas. Cost, therefore, appears to be of primary importance in fuel selection, BCI concludes.

What sort of outlets are the retail coal dealers serving? BCI's market survey turned up some 36 types of commercial, small industrial and institutional accounts. Among the 383 dealers in the 276 cities surveyed, the leaders shaped up as follows and in this order: apartment buildings, schools and colleges, churches, stores, garages, manufacturers, florists and greenhouses, office buildings, hotels, dry cleaners, laundries, hospitals, clubs and lodges, warehouses, dairies and creameries.

BCI offers various printed aids to efficient operation using coal as a fuel. The recently published boiler room wall chart on proper operation of underfeed stokers is the first in a projected series, and serves as a practical way to provide continuing help to operators. Contact the Institute, at 802 Southern Building, Washington 5, D. C.

COST PER MILLION BTU DELIVERED ($)

Area	Coal	Oil	Gas
Buffalo, N. Y.	0.482	0.734	(1)
Chicago, Ill.	0.535	0.621	0.880
Cincinnati, Ohio	0.358	(2)	0.785
Cleveland, Ohio	0.475	0.600	0.675
Detroit, Mich.	0.457	0.583	0.795
Milwaukee, Wis.	0.494	0.679	1.070
Minneapolis, Minn.	0.540	0.657	0.800
Paterson, N. J.	0.464	0.467	1.420
St. Louis, Mo.	0.296	0.505	0.666
Youngstown, Ohio	0.396	(2)	0.665

(1) No straight natural gas sold.
(2) Commercial oil use negligible.

CONSTRUCTION NEWS

Phoenix, Ariz. — The State of Arizona Power Authority has applied for a license to build a $162,000,000 low dam in Bridge Canyon just below Grand Canyon National Park. The proposed dam would be 450 ft high and have an installed capacity of 440,000 kw. It would impound about 550,000 acre-ft of storage. In addition, license was asked to build a $128,000,000 dam in Marble Canyon, just below Glen Canyon Dam, as soon as the Bridge Canyon Dam is completed. It would have a storage capacity of 324,000 acre-ft and have 340,000 kw of power capacity. Arizona's motive is to beat the City of Los Angeles, Calif, to the punch since they too have filed an application to explore the Bridge Canyon site.

Healdsburg, Calif. — Pacific Gas & Electric Co, 245 Market St, San Francisco, Calif, was authorized by the California Public Utilities Commission to build a $2,000,000 electric generating plant at this location which will use live steam from wells drilled in the earth as a power source. Plant will have an initial capacity of 12,500 kw, and company hopes to schedule completion by mid-1960. Plant location is about 80 miles north of company headquarters at San Francisco.

Los Angeles, Calif. — Los Angeles Water & Power Dept, 311 S Spring St, this city, has announced contract award to the Brown Boveri Corp, Baden, Switzerland, for the construction of two electric turbo-generators, each with an initial capacity of 200,000 kw for installation at city's Haynes Steam Plant at Los Alamitos, Calif. Cost of the units will approximate $9,260,000. The first unit is scheduled to be placed in line by early 1960 and the second unit late in 1961. Entire project is estimated to cost about $15,000,000.

Pittsburg, Calif. — Pacific Gas & Electric Co, 245 Market St, San Francisco, Calif, has authorized plans for major addition to Pittsburg Power Plant located here. Preliminary engineering work is already under way for the installation of a fifth generating unit at this location, with future plans for the sixth installation sometime early in 1960. The two units are scheduled to be completed in the summer of 1962 and when placed in line will boost plant capacity to about 1,310,000 kw. Each unit will have an initial capacity of 325,000 kw, and when completely installed, will represent an investment in excess of $76,700,000.

Stockton, Calif. — State Division of Architecture, 1120 N St, Sacramento, Calif, has authorized plans for the replacement of boiler at steam plant of the Stockton State Hospital of Mental Hygiene. Work will begin at once for completion by mid-1960. Cost of replacement estimated to be in excess of $125,000.

Atlanta, Ga. — Georgia Power Co, 52 Fairlee St, NW, this city, has authorized additional plans for extensions and improvements in company's transmission and distribution facilities. Company has appropriated a fund of $2,500,000 for the construction of a 47-mile 230,000-v electric transmission line and a 125,000-kw substation at Winder, Clayton, DeKalb, Gwinnett and Barrow counties; an amount of $1,800,000 for the construction of a 57-mile 230,000-v electric transmission line in Clayton, Fulton and Carroll counties; and approximately $3,500,000 for additional transmission lines, switching stations, substations, and other work to expand company's service lines in its service area.

Indianapolis, Ind. — Indianapolis Power & Light Co, 17 N Meridian St, has announced plans for a three year expansion program involving the expenditure of $42,000,000 to provide for the steadily increasing demand for power and electricity in company's service area. Utility plans to spend $10,000,000 in 1959, $20,000,000 in 1960, and $12,000,000 in 1961 to increase generating capacity and expand company's distribution system. Largest single item in the program is a new 111,000-kw generating unit for the company's Stout Station here. The new unit will cost approximately $16,800,000 and will be in operation by June of 1961.

Kansas City, Kans. — Board of Public Utilities, City Hall, has announced plans for major expansion and improvement of municipal power plant. City has announced contract award to the Babcock & Wilcox Co, of 1012 Baltimore St, Kansas City, in the amount of $2,596,202 for installation of a 425,000-lb steam-boiler at Kaw Power Station. Work is already under way and is scheduled for completion by the fall of 1960. Installation of a steam electric generating unit with an initial capacity of 60,000 kw will be installed by Burns & McDonnell at an estimated cost of $12,500,000.

Somerset, Mass. — Montaup Electric Co, 85 N Main St, Fall River, Mass, has awarded a $20,000,000 contract for the design and construction of a new steam-electric generating plant at Brayton Point, South Somerset, Mass. Plant will have an initial capacity of 600,000 kw. Work will get under way at once for completion in the fall of 1961. Stone & Webster Engineering Corp, Boston, Mass, has been awarded the construction contract.

Willmar, Minn. — City Municipal Utilities Commission, Willmar, Minn, will expend about $650,000 for extensions and improvements in municipal power plant, work to include installation of a new steam-electric generating unit and auxiliary equipment. Power Service Corp, Wesley Temple Bldg, Minneapolis, Minn, is in charge of construction. Work will get under way at once for completion by late 1960.

Hallam, Neb. — The Atomic Energy Commission, 1901 Constitution Ave, NW, has announced that it has selected Peter Kiewit Sons Co to act as general contractor for the construction of a nuclear power plant to be located here. The plant, when completed in 1961, will generate 75,000 kw of electricity, enough to supply a normal city of about 100,000. The reactor will be built by the AEC, which plans to sell steam for the generation of electricity to the Consumers Public Power District of Nebraska. The nuclear reactor, using an advanced sodium-cooled concept, will be designed by Atomics International, a division of North American Aviation, Inc, while the nuclear part of the plant will be built by Bechtel Corp.

Indian Point, N. Y. — Consolidated Edison Co, 4 Irving Place, New York, N Y, has announced that completion of its nuclear power plant, now under construction here, would be delayed approximately a year due to unexpected technical problems.

New York, N. Y. — The Board of Estimate of the City of New York, City Hall, has announced that it has approved contracts for the sale of the three city-owned subway power plants to the Consolidated Edison Co, 4 Irving Place, this city, for a gross amount of $125,840,000. Under the present contract, the Transit Authority, which now runs the plants, will turn them over to the Consolidated Edison Co in mid-year, but the formal transfer will take place three years later when the amount of the sale has been paid in full. As part of the contract, the power company must also assume the cost of modernization contracts totaling another $22,800,000.

Sioux Falls, S. D. — Allis-Chalmers Mfg Co, 864 S 70th St, Milwaukee, Wis, will launch research and development work on a nuclear superheater to be incorporated in an atomic power plant to be located near here. A contract will be signed by the AEC with the Northern States Power Co, 15 S Fifth St, Minneapolis, Minn, for whom the 66,000-kw Pathfinder Atomic Plant is being constructed. Allis-Chalmers, as prime contractors for the construction of the nuclear reactor for the plant, will receive about $2,500,000 for the superheater work. The Pathfinder plant is a coöperative venture of the Atomic Energy Commission, Northern States Power Co and ten other Midwest Utilities and is scheduled to begin operation in June 1962.

Washington, D. C. — The Atomic Energy Commission has authorized plans to help two private utility groups build an advanced gas-cooled reactor at a site to be selected on the west coast of Florida. Construction of the $26,000,000 plant will begin at once and will, upon completion, generate about 50,000 kw of electricity. The AEC will pay about half of the cost of research and development, estimated to be about $18,000,000, and contribute free fuel and heavy water for a total outlay of $13,200,000. Cost of the construction of the plant to be completed by mid-1963 will be financed by the East Central Nuclear Group, Inc, and the Florida West Coast Nuclear group. It will be fueled by slightly enriched uranium, cooled by helium, and moderated by heavy water.

Power Engineering handbook

How to Maintain Centrifugal Pumps

8 — Baseplate and Couplings

By J. A. CABLE* and O. M. KRISTY, Jr*

A CENTRIFUGAL PUMP and its drive are normally mounted on a common baseplate. The preferred, modern baseplate is made of fabricated steel. This construction is superior to the old-style cast iron base because it's less expensive, lighter in weight, more rugged, easily repaired if damaged, and will absorb a greater amount of distortion without failure.

Figure 1 shows a typical fabricated steel baseplate including the "drip-lip." Note the pump and motor mounting pads. Larger sizes of pump and motor require additional cross-bracing underneath to stiffen the assembly.

Most recent development (Fig. 2) is the "open" design, which embodies all of the features listed above for fabricated steel bed-plates, but it does not include a drip-lip. However, by completely filling this bed-plate with grout, a drip-catching surface can readily be formed to drain away leakage that escapes the drainage pipes directly connected to each gland sump. This type of bed-plate has the further advantage of being less expensive than the type shown in Fig. 1.

Maintenance of bed-plates is minor. However, proper installation will not only eliminate this maintenance, but will also minimize required maintenance on both pump and drive bearings, couplings, casings, wearing rings, or any close running clearance. Therefore, proper bed-plate installation is extremely important.

The foundation should provide a rigid, firm and permanent support for the bed-plate. It should also be capable of absorbing any vibration imposed by the rotating pump and drive.

Fig. 1. Welded steel base plate for mounting pump and driving unit. Reinforcing members on underside give added rigidity. Note drip trough

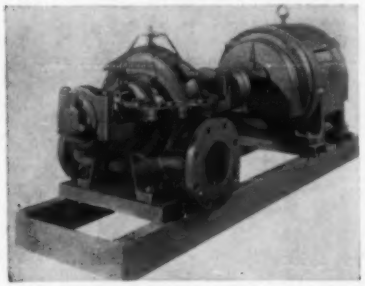


Fig. 2. Pump and motor mounted on "open" plate

*Application Engineer and Supervisory Engineer, respectively, Centrifugal Pump Dept, Allis-Chalmers Mfg Co

fold along this line—outside edges toward you

Most foundations consist of concrete laid on solid ground, bed rock or pilings. The foundation bolts should be set in concrete, accurately located from drawings or templates, and surrounded by a pipe sleeve about three diameters larger than the bolt. While the bolt should be firmly anchored in the concrete, it should be free in the pipe sleeve to allow minor shifting of the bolts to suit the bed-plate drilling.

Prior to grouting, the mounting pads or solo plates must be leveled by shimming adjacent to each foundation bolt. The shafts of the pump and driver must be level, and the coupling aligned.

Before grouting place a form around the entire bed-plate, allowing at least ½-in. of grout to come out under the bed-plate drip-lip or side rail, and fill the entire space between bed-plate and foundation. Eliminate all air pockets.

An accepted mixture of grout consists of one part of cement and two parts of sand mixed with sufficient water to allow the mixture to flow readily under the bed-plate and around the form. Sufficient "head" and agitation should be provided to be certain complete filling has been accomplished.

After the grout has set, tighten all foundation bolts securely, leaving the steel shims or leveling plates embedded in the grout.

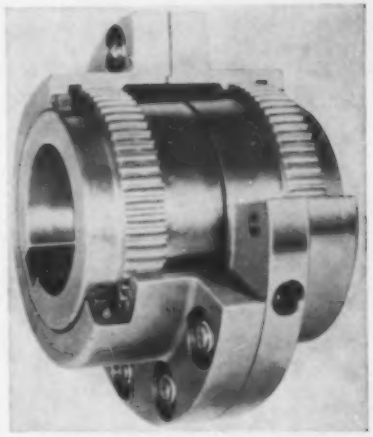


Fig. 3. Geared flexible type is in common use

Couplings

Couplings as made today should provide trouble-free service if alignment between the pump and driver is maintained, and the coupling is properly lubricated where required.

Following are four types of couplings commonly used on centrifugal pumps: 1. geared flexible type (Fig. 3); 2. Magic-Grip rubber pin and bushing type (Fig. 4); 3. Steelflex (Fig. 5); 4. flexible disc type (Fig. 6).

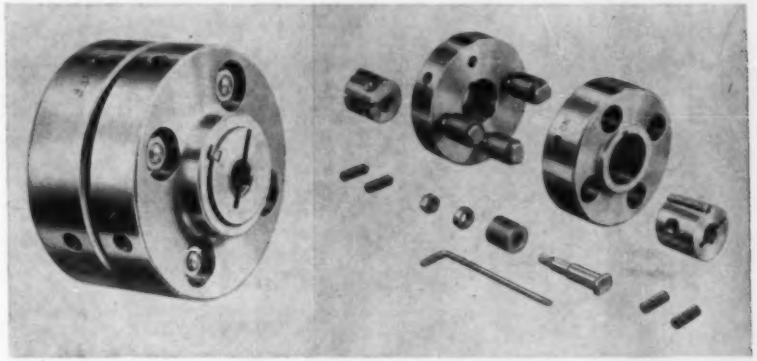
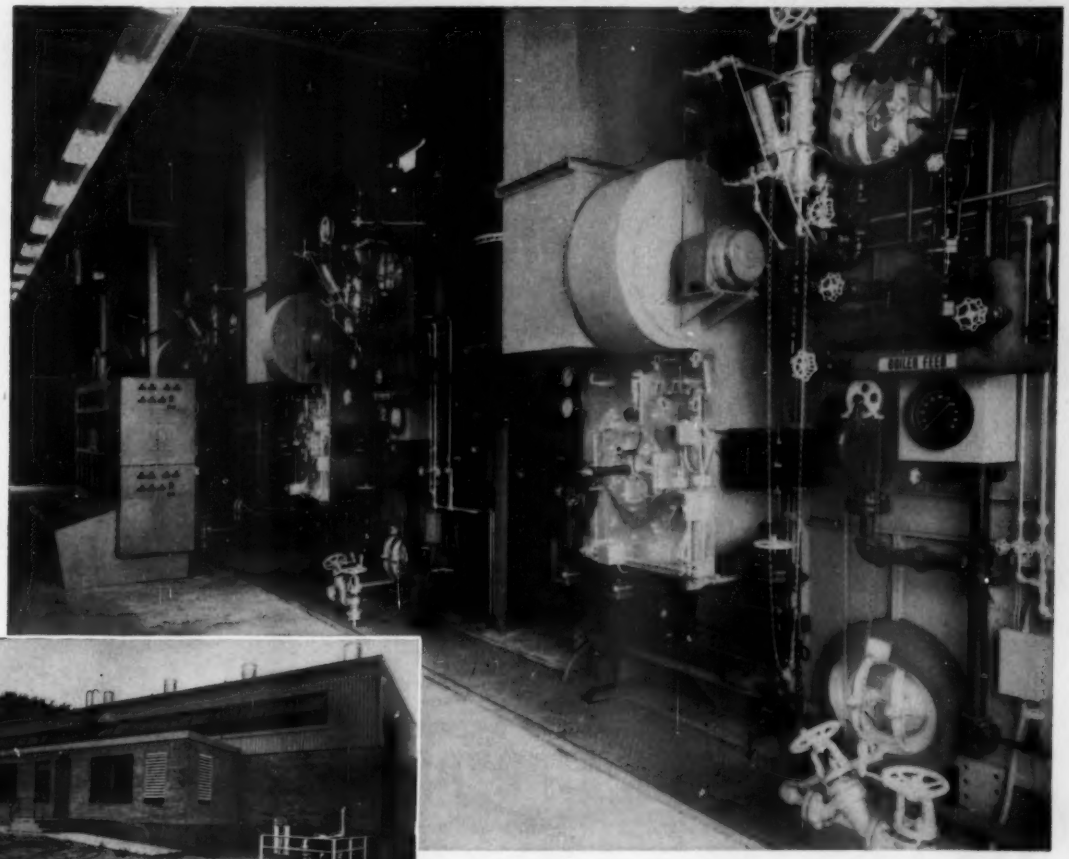


Fig. 4. Magic-Grip rubber pin and bushing type of coupling. Right photo shows component parts of uni

cut along this line

KEELER **dk** package steam generators

THE HASKELL INSTITUTE—Lawrence, Kansas
U. S. Government Indian School operated by
United States Department of the Interior, Bureau of Indian Affairs
Washington, D. C.
Arthur O. Allen, Engineering Advisor



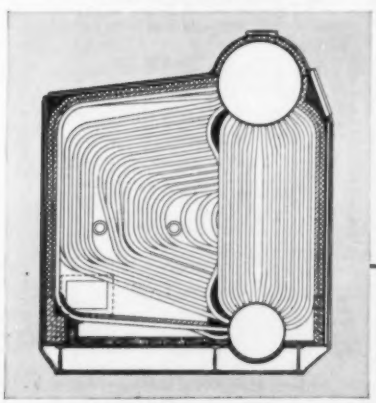
THE JIM THORPE POWER PLANT

at Haskell Institute

— Architects & Engineers —
WILSON & CO., SALINA, KANSAS

— General Contractor —
C. L. MAHONEY CO., INC., KANSAS CITY, KANSAS

— Supervision of —
Construction & Equipment Installation
BUREAU OF INDIAN AFFAIRS, BRANCH OF PLANT DESIGN & CONSTRUCTION, ALBUQUERQUE, N. M.
Edward A. Poynton, Chief



With an eye for economy and efficiency, the new central heating plant at the Haskell Institute is equipped with four multi-purpose Keeler Type D K package steam generators. They supply the entire steam needs of the several buildings at this U. S. Government Indian School located on a 280-acre tract near Kansas City.

Three of the units are 25,000-lb stm/hr capacity boilers equipped for combination oil and gas firing, and the fourth is an 18,000-lb stm/hr gas-fired unit.

A *"better efficiency than required"* report confirms the wisdom of the selection, together with further statements which indicate *a 20% drop in fuel costs,* when firing the new Keeler Type D K units at the same capacity as the previous equipment.

There's a size and type Keeler steam generator available for your requirements—up to 200,000-lbs stm/hr—with the full economy, efficiency, versatility and dependability that has earned Keeler its reputation as "builders of better boilers since 1864"! *Write or phone for free bulletins, full data and specifications . . .*

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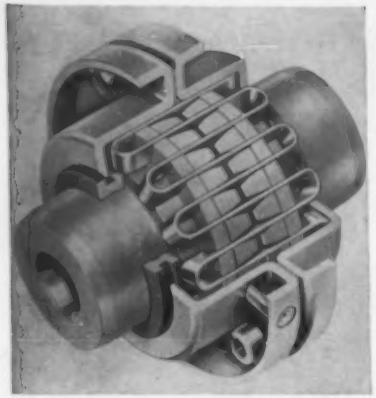
100-200 West St. - Williamsport, Penna.
— OFFICES IN PRINCIPAL CITIES —
In Canada: Canadian Vickers, Ltd., Montreal, P.Q.

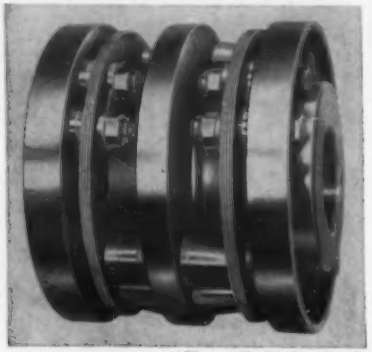
KEELER WATER TUBE Boilers

For more data circle 542 on Post Card



Falk Corp

Fig. 5. This is Steelflex centrifugal type of coupling



Thomas Flexible Coupling Co

Fig. 6. This is the flexible disc type of coupling

The geared type of coupling is made entirely of steel and consists of two identical externally geared hubs that drive or are driven by the shaft through a key. The hubs are connected and enclosed by a two-piece (male and female fitted) floating cover sleeve that is internally geared. The two-piece cover sleeve operates as a single rigid unit. It is flanged and bolted transversely at the center. The external gear on the hubs is crowned to permit freedom of movement of the split cover sleeves (operating as a unit) on the hubs.

In compensating for misalignment, the cover sleeve assumes, freely, a neutral position between the hubs. This prevents crank action and adverse stress being transmitted to the shafts and bearings.

This type of coupling requires lubrication to allow proper operation. A gasket is contained (by bolting) between the cover sleeve flanges, and a neoprene seal at the hubs contains the lubricant and keeps out dirt. The two oil plugs (for lubrication) are sealed with a copper gasket.

For proper lubrication a high grade non-separating ball bearing grease should be used or a good fluid lubricant no lighter than a heavy engine oil (S.A.E. 70) or heavier than a heavy gear oil (1000 S.S.U. at 212 F).

The torque load is driven by shaft keys through the gear teeth, the thrust load being taken by the butting hubs or shaft ends in one direction and the cover sleeve assembly in the opposite direction. Limited end float is provided by selective placement of the hubs on the shaft ends (to control amount of "float" in cover sleeves) and either shaft protrusion or "buttons" (to control distance between shafts).

Magic-Grip

The Magic-Grip rubber pin and bushing coupling (Fig. 4) consists of two cast discs (items 2 and 3), and two Magic-Grip bushings (item 1). The bushing is of the split type, which allows it to slide easily on the shaft. The outer diameter of the bushing and inside diameter of the coupling discs are tapered. There are four drilled recesses in the bushing (item 1) which accommodate the off and on position of the set screw holes of the coupling (items 2 and 3).

The recesses in the bushings are offset in such a manner that when the set screws are tightened, the bushing will either draw in on the taper and tighten on the shaft or push out of the taper and loosen on the shaft.

The rubber pin and bushings (items 4 and 5) are assembled and fastened to disc (item 2) as shown in Fig. 4. No lubrication is required for this type of coupling, although the rubber bushings, and possibly the pins, will have to be replaced due to wear. The time element depends upon how well alignment is maintained during operation.

fold along this line—outside edges toward you

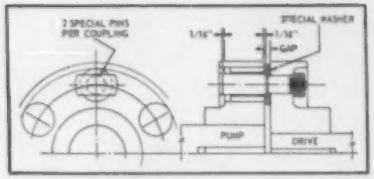


Fig. 7. Plan showing location of thrust pins used to contain the thrust in the Magic-Grip coupling

The torque load is carried by the pins and bushings from driver hub to driven hub. The thrust load can be confined by two diametrically opposite thrust pins and the "bumping" of shafts. See Fig. 7 for location and installation of the thrust pins used to contain the thrust if the coupling hubs pull apart.

Steelflex Coupling

The Steelflex coupling (Fig. 5) consists of two steel hubs each of which contains teeth on the outer periphery. These teeth are especially shaped to hold steel grid-members that carry the driving torque. Steel half-covers which are bolted together contain the lubricant and grid-members. The bolting joint contains a flat gasket, while neoprene seals are used between each cover bore and hub turn.

A grease lubricant is required on the grid-members to allow proper operation, due to motion between grid-members and hub teeth. Thrust load on this type of coupling is contained in one direction by butting of the coupling hubs or shaft ends (with the load being carried by the pump thrust bearing) or by the grid-members as the two coupling hubs pull apart.

To limit the axial end float of the couplings, rung spacers can be provided with each coupling designated for limited end float. The rung-spacers are made of neoprene and are inserted in the grid-member to reduce axial movement between grid-member and gear-teeth flange. The size of the rung-spacer will be determined by the amount of axial float desired in the coupling assembly.

Flexible Disc Type

Flexible disc type of coupling consists of two steel hubs (Fig. 6), a center member and two sets of multiple, flexible disc rings. The individual sets or groups of flexible discs are alternately bolted to one side of the center member and one hub flange. The other set or group of flexible discs are alternately bolted to the other side of the center member and the other hub flange. Thus, torque is transmitted through one hub flange to a set of flexible discs, to the center member which transmits it to the second set of discs, and on to the driven hub. Thrust and misalignment are also carried through this path.

Because there are no moving parts (other than flexing of the discs) no lubrication is required for this type of coupling. The torque is carried by the hubs, flexible discs, and center member. The end float is free within limits and resists thrust with increasing force between the neutral position and the two extremes of permissible end float.

The disc type of coupling is inherently a self-centering coupling and complies with all the NEMA specifications. This type of coupling needs no further limiting devices for end float.

No matter how you add it up, couplings of all types will require a minimum of maintenance if pump-drive alignment is sought in the original installation and then checked periodically to see that it is kept.

Cable and Kristy's series of articles

MAINTAINING CENTRIFUGAL PUMPS

began in the October 1958 Handbook and has covered the following topics:

October, 1958	**Stuffing Boxes Fitted With Packing**
November, 1958	**Stuffing Boxes With Mechanical Seals**
January, 1959	**Shafts and Sleeves**
February, 1959	**The Impellers**
March, 1959	**Wearing Rings**
April, 1959	**Bearings**
May, 1959	**Casings**

Two more chapters will complete the series. If you would like extra copies of any of these articles, write the Editor, POWER ENGINEERING, or jot Centrifugal Pumps on the post card enclosed in this issue.

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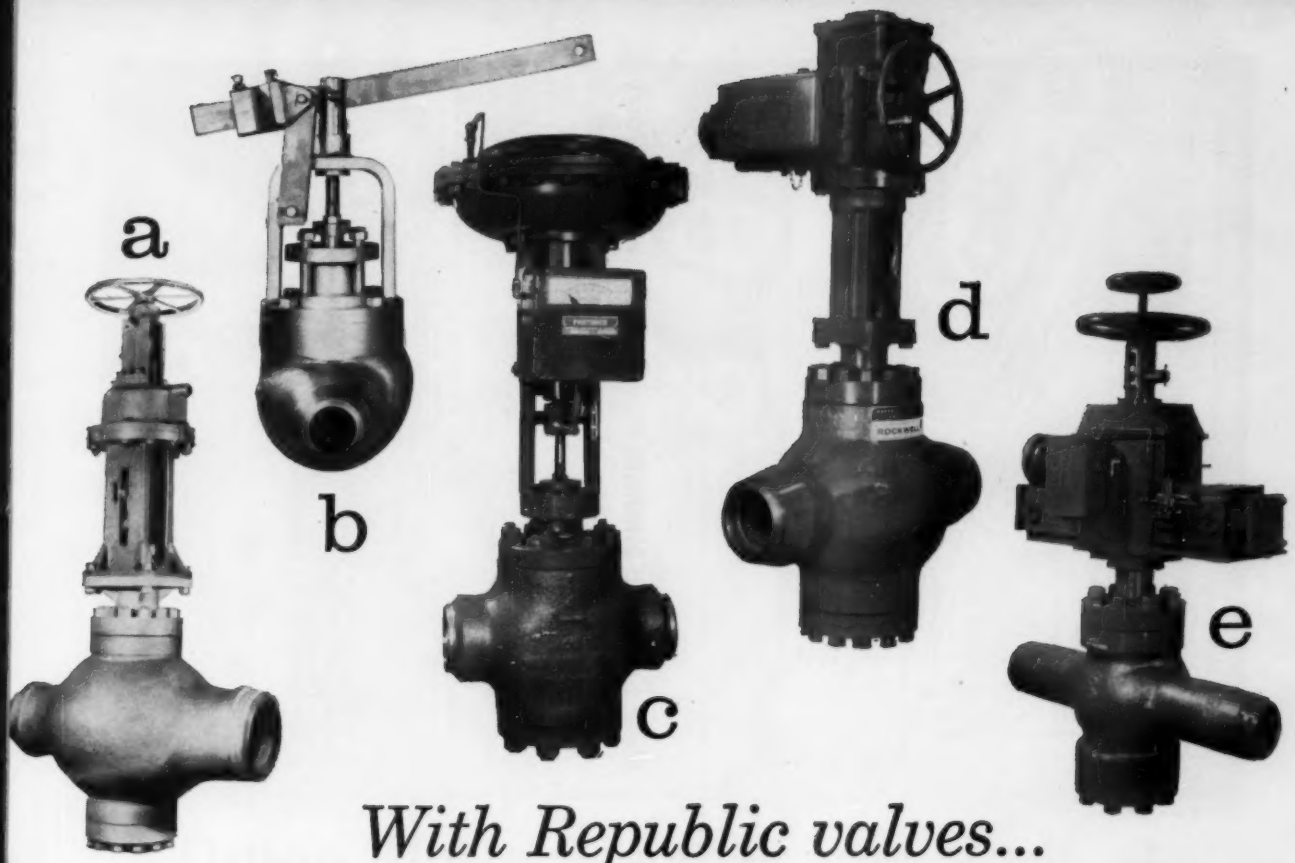

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Wide selection of valves and features—Rockwell-built Republic regulating valves shown on this page are representative of the complete Republic line:

a. **Cylinder operated valve**
b. **Lever operated valve**
c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

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Whatever your regulating valve problem, let Republic engineers put their years of application experience to work for you. For additional information, see your Republic representative, or write to Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois.

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How to Keep Oil Burners From Plugging Up When Switching From Gas to Oil

By F. E. ZIEGELMANN *

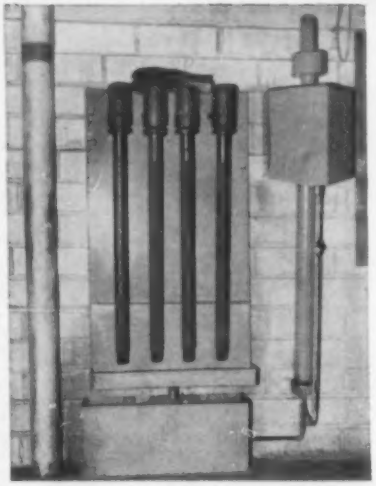

Fig. 1. Oil burner cleaner stands beside rack. Low pressure air is supplied at bottom connection

WE USE OIL as a stand-by fuel in our plant, and were having difficulty in switching over from gas to oil due to deposits and scale plugging up the burners right after lighting off.

When making preparations for switching fuels, the heaters were turned on and oil (we use Bunker C) was recirculated right up to the burner manifold to heat and clear out lines. Steam atomizing lines were blown down to clear them also. Due to the fact that the oil burners stand idle most of the time, deposits and rust would form.

We tried blowing out the burners with air before lighting off, but this had no effect. After numerous failures we completely dismantled a burner, for it was obvious that something would have to be done to keep burners ready-to-use.

Figure 1 shows an oil burner rack alongside an oil burner cleaner we have fabricated. As Fig. 2 shows, low pressure air (10 lb to 15 lb) is supplied at the bottom connection. As air flows past the flared tubing, a suction effect is created on the reservoir recirculating line. Thus a spray and fine mist is directed at the burner tip and from which sprayer plates have been removed.

Only way for the spray and fine mist to get into the air space above the reservoir is to go through the steam and oil passages of the burner; and this it does nicely, washing all the surfaces of the burner as it passes through. The burner is allowed to be cleaned for 15 to 20 minutes, then is moved to the burner rack to drain thoroughly, leaving a thin coat of oil on all surfaces when it dries.

Since we have installed the cleaner, we have had only one failure and believe that this was due to the burner not having been washed long enough.

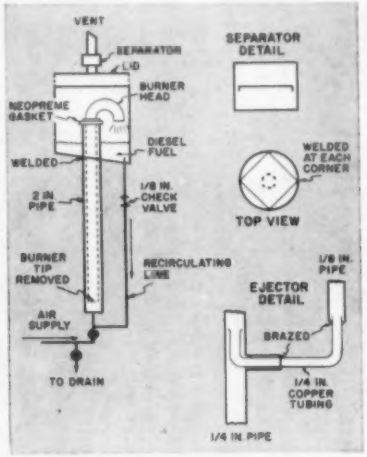

Fig. 2. Scheme of oil burner cleaner, side view. The ⅛-in. check valve is installed to keep initial surge of air from backing up into reservoir

* Powerhouse Engineer, Delco-Remy, Anaheim, Cal

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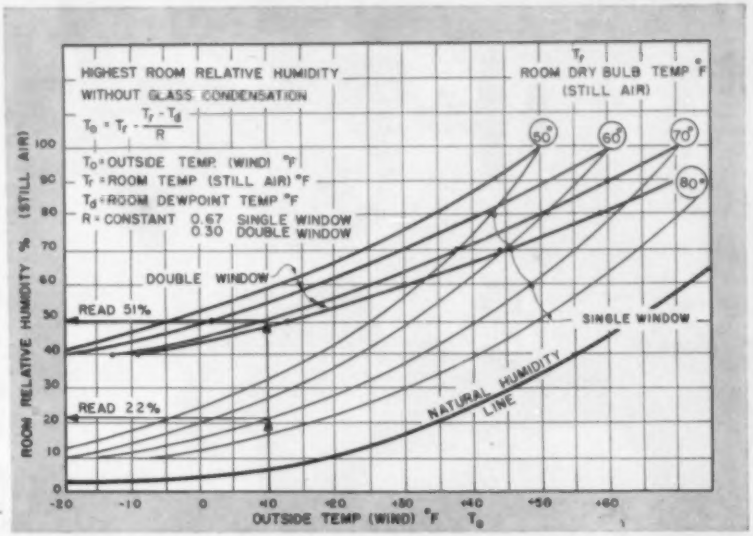

HIGHEST ROOM RELATIVE HUMIDITY WITHOUT GLASS CONDENSATION
$T_o = T_r - \frac{T_r - T_d}{R}$
T_o = OUTSIDE TEMP (WIND) °F
T_r = ROOM TEMP (STILL AIR) °F
T_d = ROOM DEWPOINT TEMP °F
R = CONSTANT 0.67 SINGLE WINDOW
0.30 DOUBLE WINDOW
T_r ROOM DRY BULB TEMP °F (STILL AIR)
50°
60°
70°
80°
DOUBLE WINDOW
SINGLE WINDOW
READ 51%
READ 22%
NATURAL HUMIDITY LINE
ROOM RELATIVE HUMIDITY % (STILL AIR)
OUTSIDE TEMP (WIND) °F T_o

Example: Outside 10 F, inside 70 F; what increase in R.H. can be carried with double windows? Answer: see curves. Single window, 22 per cent; double window, 51 per cent, or a difference of 29 per cent R.H.

How to Figure Highest Room Relative Humidity Without Glass Condensation

By JOHN D. CONSTANCE, P.E.

FREQUENTLY, in heating and air conditioning systems, the engineer must determine the conditions under which moisture or frost will be deposited on the inside of the glass windows. He may wish to know what relative humidity he can carry against a given outside temperature without deposit of moisture. Or he may want to know how far the outside temperature can drop before window condensation will take place.

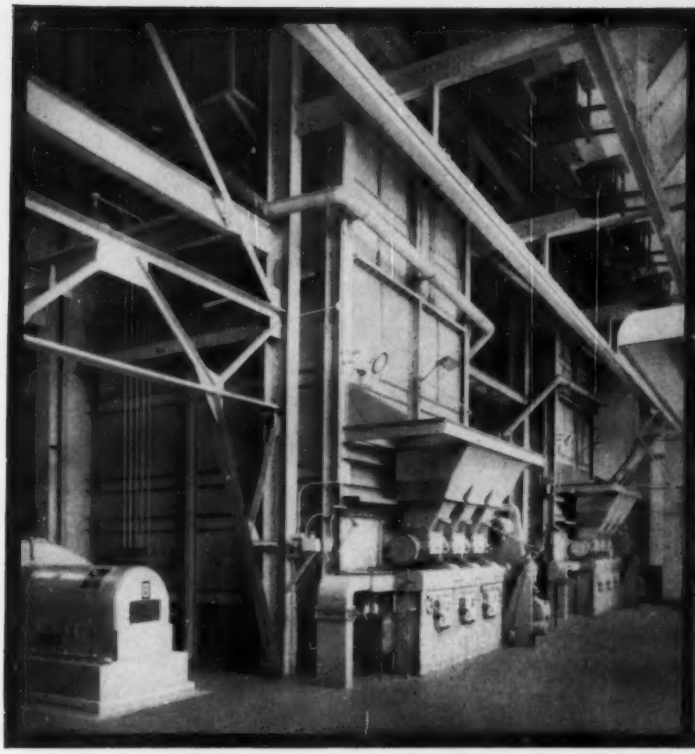
The chart gives all the answers for single-glass windows and double-glass windows (windows with storm sash). Outside temperature is at 15 mph wind; inside room temperature is with still air (50 fpm). Natural humidity line is shown as a guide and is for average outside conditions.

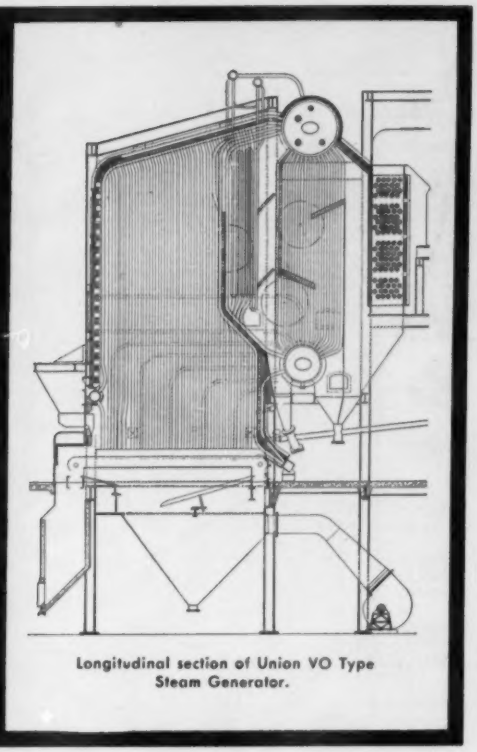
The equation may be used to find conditions beyond the scope of the curves. For glass block, curves for double-window are too high by about 10 per cent relative humidity. Under critical conditions, moisture will condense out at the mortar joints.

Referring back to the curves, a lower outside wind velocity will raise the allowable relative humidity that can be carried, while a higher air velocity over the inside surface of glass gives similar results in raising humidity.

However, heat loss through the window by transmission is increased. A tight seal around the room side of the double-window will effectively reduce condensation on the inside surface of the outer pane. Ideally, both windows should have seals that are tight, but sealing the inside is more important, leaving the outside with weep holes to drain off accumulations of rain or condensation.

cut along this line





Longitudinal section of Union VO Type Steam Generator.

Union Boilers score new high at Notre Dame with 83% efficiency

Spread over a 1700-acre campus near South Bend, the University of Notre Dame is a self-sustaining community of 6,000 students and 500 faculty members.

To meet the demands of increasing enrollments, as well as to handle its own power requirements, the University expanded its steam heating plant and converted it to a steam-electric power plant. Three of the four original boilers were replaced with a pair of Union 2-drum VO Type Steam Generators. Spreader-stoker fired, each unit is equipped with a superheater and an economizer. Normal rating is 70,000 lbs./hr. at 470 psi and 750° F.

Although the heating load is increased 20%, and electric power is now supplied for all 75 buildings on the campus, boiler efficiency has been upped from 68% to more than 83%. *Coal consumption remains unchanged!*

This is just one job report where Union efficiency and dependability have achieved top-notch economy of operation. Across the nation, Union Boilers are giving similar service to industrial, institutional and public power plants, providing day-in and day-out, the best performance value in modern steam generating equipment.

GET FULL DETAILS

Information on the several types of steam generators built by Union is yours for the asking. Write for illustrated Catalog GB-153.

Aerial view of Notre Dame — with 75 buildings on a 1700-acre tract, this campus is a city in itself.

Steam-electric power plant makes campus community independent of outside power sources.

UNION

UNION IRON WORKS

ERIE, PENNSYLVANIA

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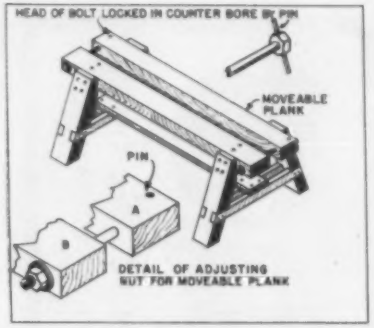


Fig. 1. Moveable plank acts as a vise to hold work or will permit center sawing or cutting of work

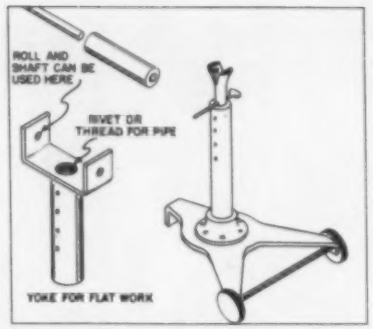


Fig. 2. Stand like this is very useful for armature overhaul, crank shaft, other maintenance

Two Ways to Make Shop Work Easier

By CHARLES H. WILLEY

RUGGED construction of the workhorse (Fig. 1) and its moveable, open-and-close plank permit it to handle work as a vise. The bolts that operate it are locked in counter bores. The socket wrench operating the bolt nut should be a T-type, and can be handily attached to the horse. The moveable plank is generally left open, to accommodate rip saw work.

The type of workstand shown in Fig. 2 has proved its worth, especially during overhaul work. It can be made from material at hand in any plant. A wide variety of attachments can be made for it, according to shop needs.

Here's Rapid Way to Calculate Required Steam Quantity

By H. B. WAYNE

ESTIMATING required steam quantity to satisfy process and comfort heating needs is a straightforward but time-consuming procedure. When different pressures are being considered, available temperature, latent and total heats need to be determined. These data are required to permit calculation of steam flow rates and heat transfer areas. Also, specific volume is a necessary parameter for sizing pipe and tubing.

The chart opposite is a plot of temperature, total and latent heats and specific volume as functions of steam pressure, with the latter expressed as gage and absolute units. Although the values may be obtained from steam tables, use of the chart enables rapid selection without need for interpolation and/or extrapolation.

Since high pressure and superheated steam have limited application for process and comfort heating services, the plot shows maximum pressure at 400 psig and thermal properties for saturated steam only.

Here are examples of chart use:

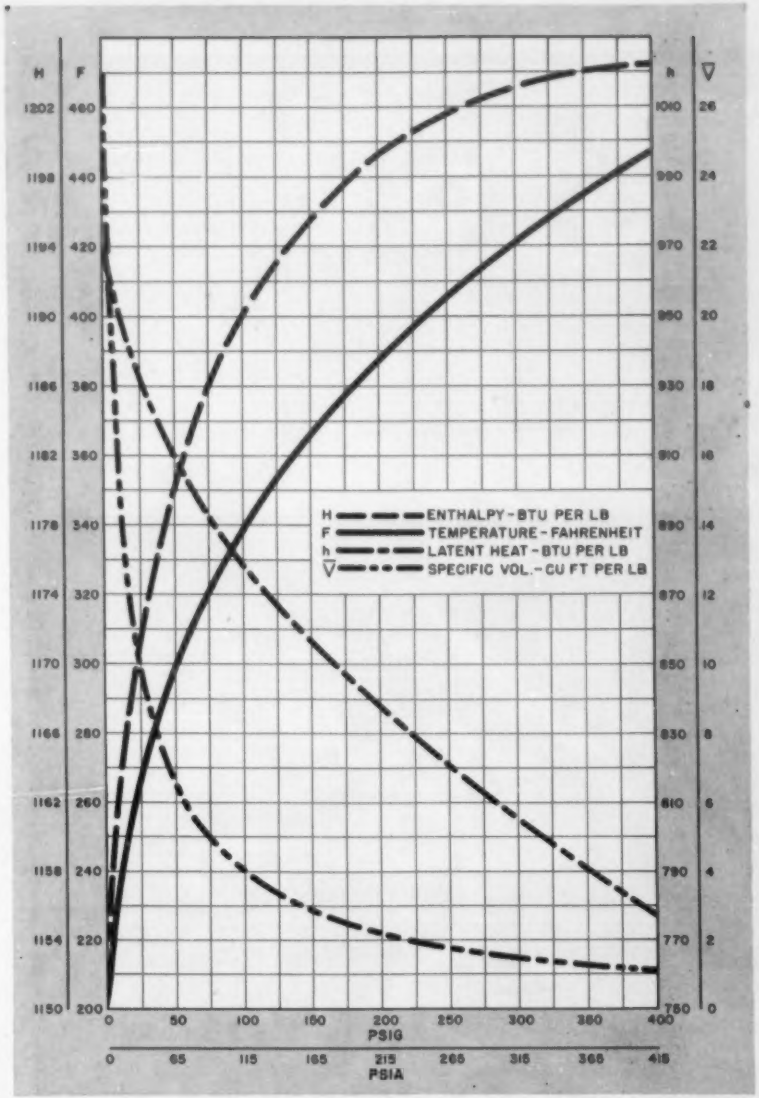
1. What temperature and latent heat are available with steam at 215 psia?

From chart, 387.8 F and 837.4 Btu per pound.

2. Steam at 350 psig may be obtained for heating service. For what temperature, total heat, latent heat and specific volume should the equipment be designed?

Answers: 435.7, 1204 H, 790 h and 1.2 V respectively.

fold along this line—outside edges toward you



This chart is a plot of temperature, total and latent heats and specific volume as functions of steam pressure, the latter being expressed as gage and absolute units. Chart avoids need for interpolation

cut along this line

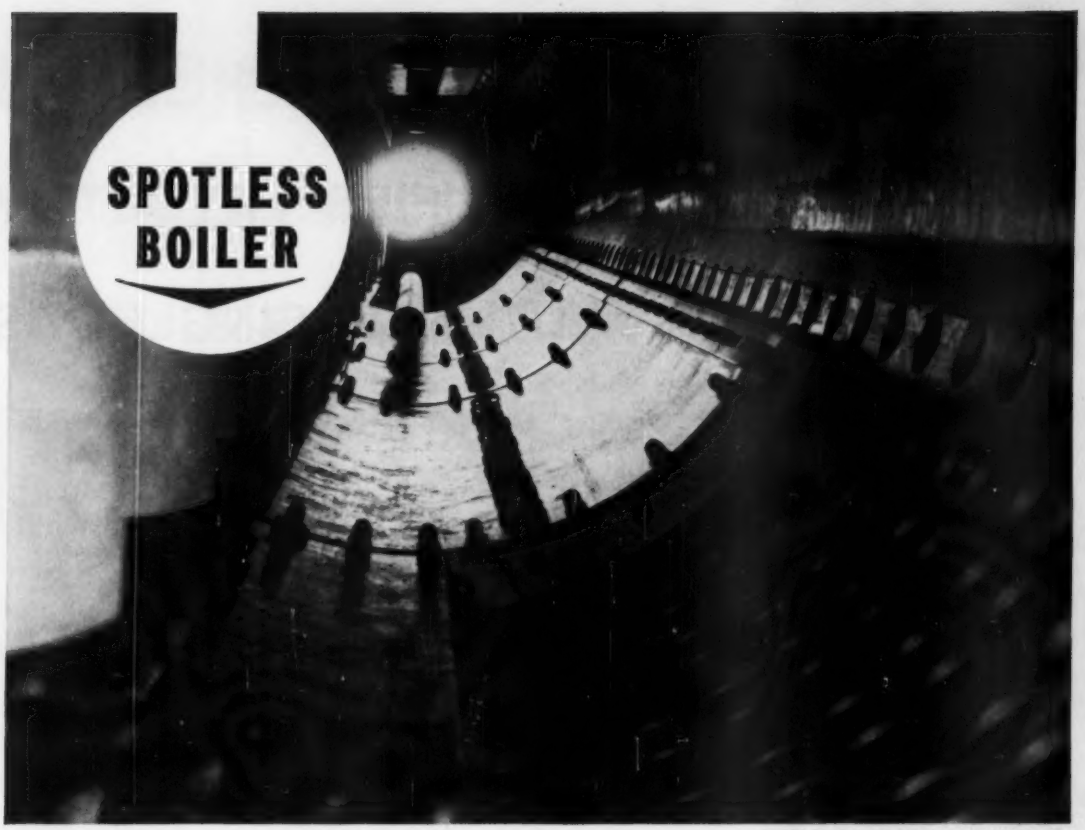
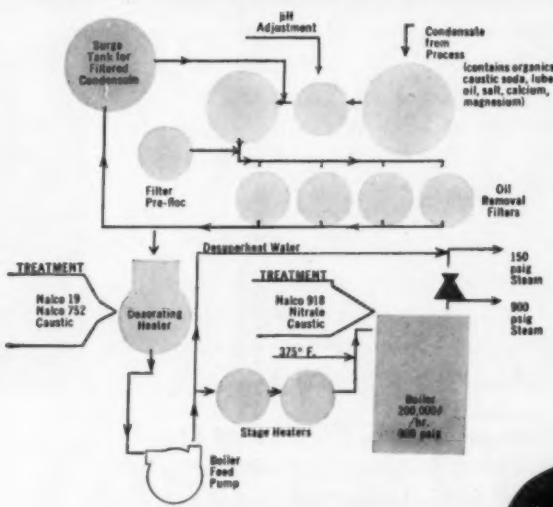


PHOTO COURTESY OF THE DOW CHEMICAL CO.

even though it operates on Contaminated Condensate!



FEEDWATER FLOWSHEET...

Pittsburg, California Plant of The Dow Chemical Co.

Nalco's continuous advisory service, easily as important as chemicals in solving this problem of contaminated condensate, simply doesn't fit into a chart. Consulting Service, in any water conditioning program, complements equipment and specialized services. It is part of the Nalco package . . . of results!

Contaminated condensate from process systems presents a complex water conditioning problem for boiler plant operators. In this system the solids in raw condensate run 15 to 80 ppm. Contaminants are lube oil and other hydrocarbons, caustic soda, salt, and traces of calcium and magnesium . . . a topnotch formula for promoting scale and sludge formation.

Working closely with a superbly cooperative plant operating staff, a Nalco Representative developed the water treatment plan. He provided the continuous counsel and coordination that keeps the boiler as it is shown here: free of sludge and scale . . . clean-to-metal after a full year's operation.

You, too, can count on the Nalco System for permanent, economical answers to water treating problems. Write or 'phone for details.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

6224 West 66th Place • **Chicago 38, Illinois**

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany

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Nalco

SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

Nalco CHEMICALS

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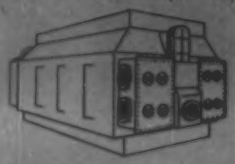
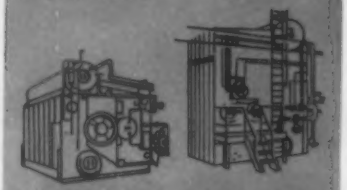
Power Plant Products

HEAT ENGINEERED BY FW



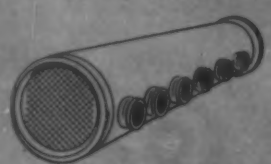
CONDENSERS and HEATERS—Condensers custom designed for individual plant requirements. All-welded high and low pressure feedwater heaters.



PACKAGED and FIELD-ERECTED BOILERS—Compact, economical, standardized units in capacities from 10,000 to 450,000 lb/hr oil, gas or pulverized coal fired.

LARGE STEAM GENERATORS—Designed to meet all requirements for Central Station or Industrial power plants, in single- or twin-furnace designs, with or without reheat or dual circulation.

COOLING TOWERS—Induced draft counter flow towers of all-redwood construction for maximum dependability and long service.



NUCLEAR COMPONENTS—Heat exchangers, steam generators, pressurizers, reactor vessels, separately-fired superheaters for stationary and marine power plants.

PULVERIZED FUEL SYSTEMS—Completely engineered systems utilizing FW ball mill or MB planetary roll and table pulverizers.

HEAT ENGINEERING

SIMPLIFIES LAYOUT and

WITH NEW SINGLE-PASS,

Compact shells use economical short tubes, eliminate two waterboxes, simplify valving. Balanced back pressure and built-in backwashing system offer further advantages for Alabama Power Company's Barry Steam Plant, Unit No. 3.

Problem: Alabama Power Company and Southern Services, Inc., Engineers, specified that the dual exhausts of the 225,000 kw turbine be handled with condenser tubes at right angles to the turbine shafts —in the tight confines of a plant extension for Barry Steam Plant, Unit No. 3.

Solution: Heat Engineering by Foster Wheeler

By application of the established principles of Foster Wheeler condenser design, a most economical arrangement for a twin bottom-exhaust turbo-generator set with tubes at right angles to the turbine shafts was provided. It features short tube lengths, complete backwashing and a minimum number of waterboxes for a twin-shell design.

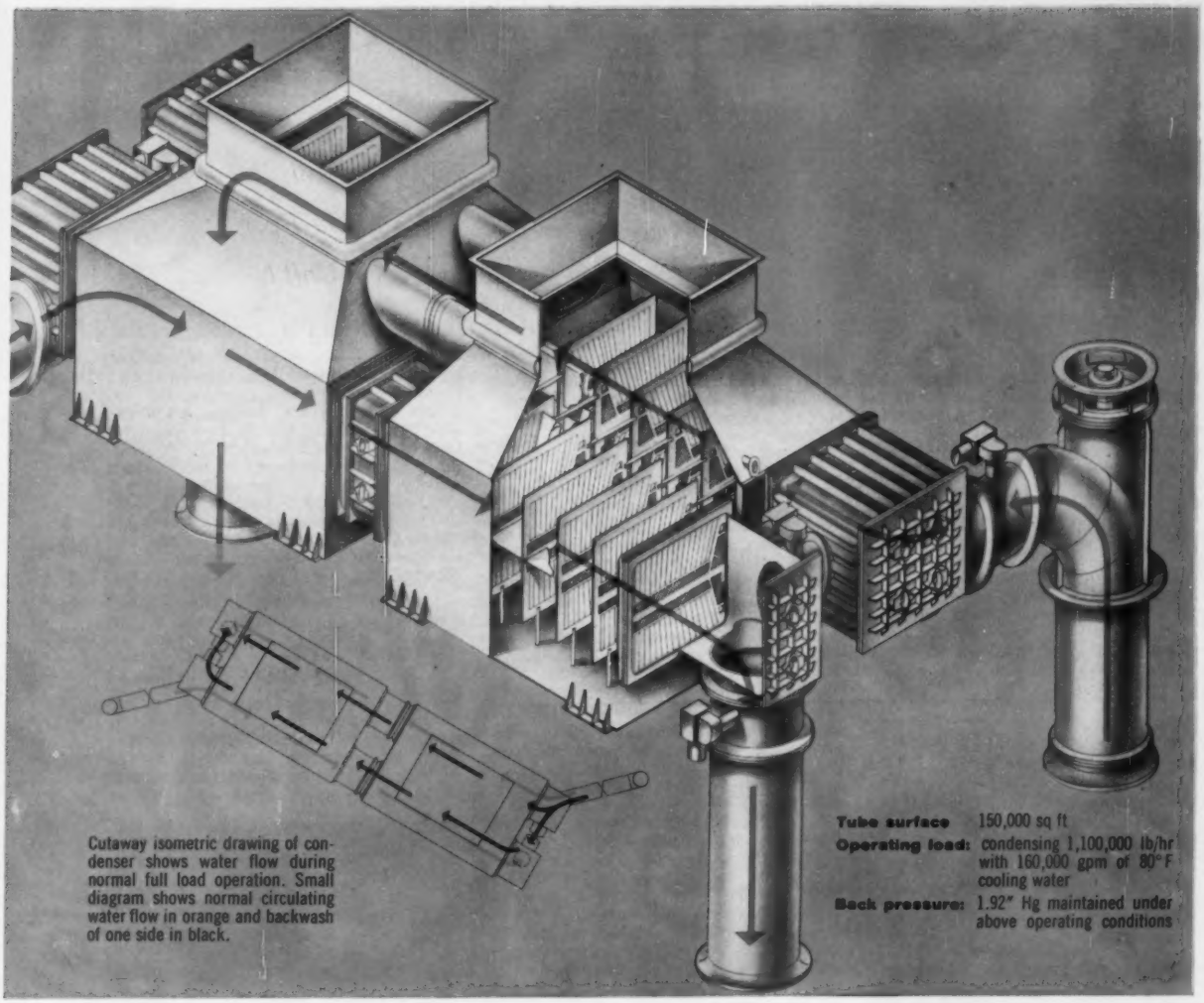
Backwashing of the tube sheets is obtained with only six valves, two of which are the normal circulating pump shut-off valves. This valving arrangement also allows the complete condenser to be operated at light loads with only one circulating pump.

In design advances such as this, you see Heat Engineering at work. This is the concept you can expect—combining new and original ideas with proved engineering principles—when Foster Wheeler serves you. *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.*

BY FOSTER WHEELER

REDUCES CONDENSER COSTS

COUNTER-FLOW DESIGN



Cutaway isometric drawing of condenser shows water flow during normal full load operation. Small diagram shows normal circulating water flow in orange and backwash of one side in black.

Tube surface 150,000 sq ft
Operating load: condensing 1,100,000 lb/hr with 160,000 gpm of 80° F cooling water
Back pressure: 1.92" Hg maintained under above operating conditions

FOSTER WHEELER

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EQUIPMENT NEWS

Described on these pages are new and improved products. Use Reader Service Cards on pages 125–126 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

1—SECONDARY INDICATOR duplicates primary readings

Similar to company's standard electronic secondary indicator but about one-quarter the size, the Yarway Miniature Indicator is designed to duplicate readings from a primary liquid level indicator or differential pressure transmitter anywhere in the plant. Outstanding feature of the miniature design is substitution of a transistorized amplifier in place of the vacuum tube design in the full-size model. The new unit is completely integrated, weighs about 5 lb; face dimensions are 2½ in. wide by 6¼ in. high. It is suggested for instrument panels where fluid lines under pressure are undesirable, for remote locations where distance precludes use of pressure tubing, where freezing may be encountered, and where installation is far above actual liquid level. Details are in Bulletin WG-1824. Yarnall-Waring Co.

2—MULTI-PURPOSE LUBE is lithium-based product

Keystone No. 88 has application in 90 per cent of all ball and roller bearing installations, says manufacturer, and produces superior results in plain bearings, needle bearings and on rotating surfaces. It is described as smooth, nonfibrous, homogeneous and odorless, — a high film-strength, lithium based product with good water repellent properties and unaffected by exposure to damp atmospheres or direct contact with water. Operating temperature range is given as 0 to 275 F, melting point near 400 F. Keystone No. 88 is claimed to resist erosive effects of hot water and steam, and to be unaffected by mild acid and alkali solutions. Six densities range from medium to light. Keystone Lubricating Co.

4—SINGLE-PHASE CONTROL for load transfer application

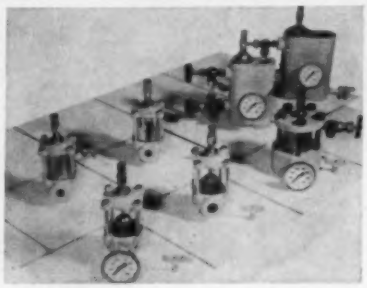
This single-phase control, designated the Type S, is designed for automatic transfer of important loads from one distribution line to another. It features easy selection of various operating sequences, enclosed relays, dead-front construction, and a hinged panel for quick access to internal wiring. The Type S is intended for use with Kyle Type NR or VR oil switches, Type B or W reclosers, circuit breakers, or other switches. It is rated for operation from 60-cycle, 120-v, a-c sources. Time delay, provided to insure coordination with backup protective devices, ranges from 2 to 57 or 10 to 285 sec. Line Material Industries, McGraw-Edison Co.

5—LEAD PUTTY works without heat, pressure

Devcon L is announced as a putty-like material, 94 per cent lead and 6 per cent plastic, which can be formed into any shape without heat or pressure. According to company, it becomes a tough, durable mass similar to lead itself 2 hr after addition of a hardening agent; once hardened, it can be drilled, sawed, or otherwise machined. Devcon L is said to have high impact, compression and tensile strengths, and to resist most solvents and chemicals. Manufacturer says it bonds lead, steel, aluminum, bronze, brass, wood, iron, porcelain and other materials to themselves or each other. Uses include repairing lead tanks, splicing and repairing lead cables, other maintenance work. Because it contains no volatile solvents Devcon L is non-shrinking and nonflammable, it is pointed out, and because it can be shaped to exact forms, it has application in making shields against radioactive materials. Devcon Corp.

6—ADJUSTABLE ORIFICES for condensate drainage

Designed to provide more accurate drainage of condensate from heating and processing units operating at pressures between 5 and 400 psi, these micro adjustable orifices are said to require virtually no maintenance and offer precise adjustment for minimum steam

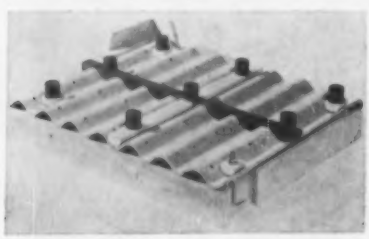


loss. A needle valve permits adjustment to regulate flow of condensate, and to prevent unauthorized changes; this requires a special key. Orifices are available with thermometer to show temperature of condensate leaving the processing unit. This temperature corresponds closely to that in the unit itself. On low pressure models, self-cleaning sight glasses permit visible operation of the valve. Orifices come in seven styles and six sizes for ½- to 2-in. pipe. Stickle Steam Specialties Co.

7—PAINT SPRAY HOSE costs less, takes more punishment

Synflex Universal Spray Hose is announced as a flexible nylon formulation, unaffected by solvents, paints or thinners, corrosion or industrial atmospheres. There is no dimensional change through action of heat or solvents,

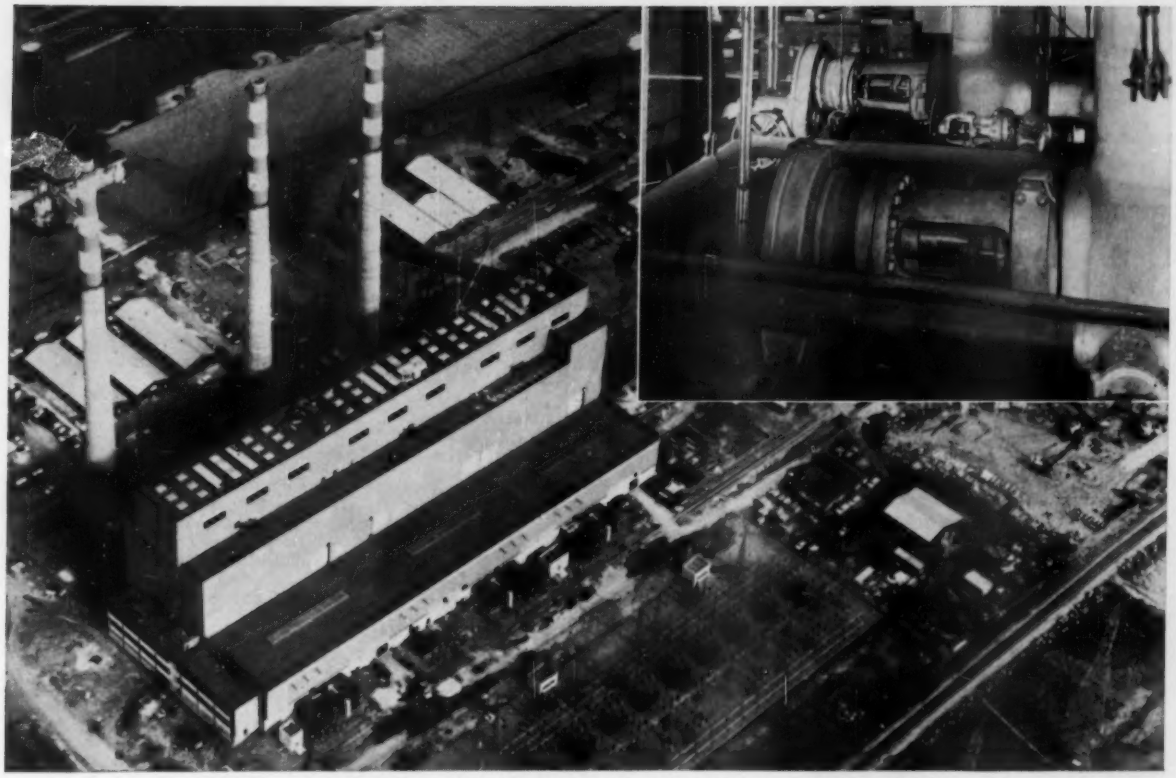
manufacturer claims, and besides costing less, this hose offers several advantages over conventional rubber or rubber-composition hose. These include extremely light weight; chemical inertness, permitting use with paints, lacquers, acrylic lacquers, enamels, plastisols and varnishes; high internal abrasion resistance, permitting use with



3—NON-CORROSIVE UNDERDRAIN for rapid sand filters

Corru-Drain is made of corrugated asbestos-cement sheets with the corrugations forming the laterals. Advantages announced include light weight, toughness, ease of shipping and handling, and simplicity of installation. Its design is said to provide for optimum backwashing distribution because of the method of orifice arrangement. It can be installed in new filters or replace underdrains in existing ones with minimum structural changes. A field comparison is reported to show 72 man-hours required to install a 342 sq ft Corru-Drain unit of 1,000,000-gal capacity, while installation time for a competitive underdrain in an identical filter came to 168 man-hours.

Corru-Drain does not require leveling, reinforcing rods, presetting of anchor bolts, extensive form work or concrete piers, or access man-holes, company points out, and installation can be started right after filter forms have been removed. Installation consists of preassembling anchors to the corrugated sheets, setting underdrain in place, caulking the seams and installing anchor bolt insulator caps. Corru-Drain's light weight contributes to lower shipping costs — a 1,000,000-gal unit weighs 2500 lb and requires a volume of only 33 cu ft for shipping. Manufacturer states that corrosion difficulties are non-existent with this underdrain system because no metal parts come in contact with water. Graver Water Conditioning Co.



Thomas H. Allen Generating Station—Memphis Light, Gas & Water Division—City of Memphis, Tenn.
Burns & Roe, Consulting Engineers. Generating Capacity: 862,500 kw. Insert shows some of the 8000 Crane valves installed in plant.

Crane builds giant pressure-seal bonnet valves for giant Memphis power plant

The Thomas H. Allen Electric Generating Station, pride of Memphis, Tenn., is the largest municipal power plant ever authorized at one time. This huge, 121-million-dollar project, in full operation, has an output capacity of 862,500 kw.

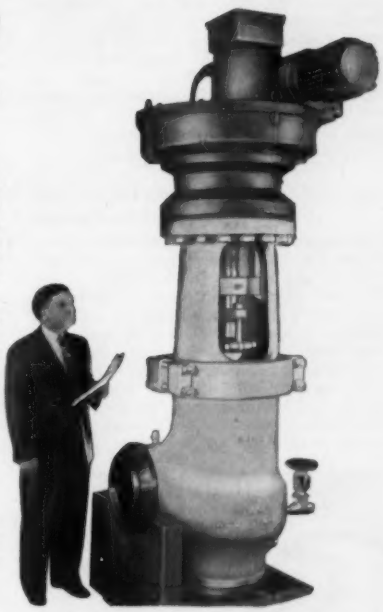
Piping plans for this immense plant called for 24 16-inch, motor-operated high-pressure/temperature angle valves—*largest valves of this type ever to be made.* They were for service on the inlet and outlet ends of 12 high-pressure, multiple-pass feed-water heaters.

Crane built all 24 valves—in pressure-seal bonnet design. These valves can handle a flow of two million pounds per hour at 585° F. and are designed for tight shutoff at 2840 psi under the disc. Special motor-operators had to be developed to provide the 500,000-pound thrust required for closing.

8000 valves—mostly Crane

In addition to supplying these 24 specially made angle valves, Crane also furnished most of the approximately 8000 other valves used on the job—carbon steel, alloy steel, iron and bronze.

Who but Crane has the modern facilities—in metallurgy, casting, inspecting, testing and other manufacturing procedures—for producing quality valves in *any* size, to *any* specifications, in *any* quantity on *schedule!* For details, consult your Crane Representative.



One of the 24 16-inch, motor-operated pressure-seal bonnet angle valves made specially by Crane. Stands 11 feet high . . . weighs 11,000 pounds.

CRANE® VALVES & FITTINGS

PIPE • PLUMBING • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill.—Branches and Wholesalers Serving All Areas

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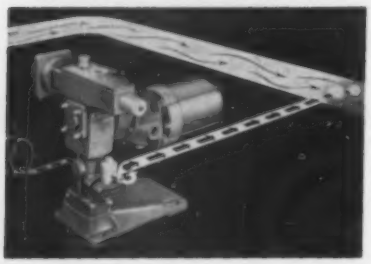
porcelain finishes; high resistance to kinking or external abrasion. Synflex Universal Spray hose is a translucent white in color with maximum operating temperature above 150 F. It comes in five sizes from 1/8 to 3/8 in. ID. Synflex Products Div., Samuel Moore & Co.

8—LEVEL CONTROL PILOT has adjustable proportional band

By means of a single knob adjustment the proportional band of the Level-Matic Pilot can be set while the liquid level system is in operation without affecting liquid level set point. Employing the differential pressure sensing method, it is claimed unaffected by surface turbulence and does not require floats, cages, linkages, torque tubes or stuffing boxes. Only two small connections to the vessel are required. Data Bulletin 583 covers this. Leslie Co.

9—METERING PUMP is compact, packless unit

The Pneumatic Stroke® Controlled McCannameter automatically proportions chemicals to any main line flow, it is announced. Utilizing its pneumatic stroke controlled instrumentation, the



pump is designed to maintain a constant discharge in proportion to the main line flow. Operating on a 3-to-15 psig air signal, the instrument requires no additional power source of air, responds instantaneously to eliminate backflash and maintain chemical-discharge-to-flow ratio, it is noted. Hills-McCanna Co.

10—SIMPLE TOOL cuts holes and shapes in metal plate

Costing about $40.00, Or-O-Co is introduced for cutting precision holes and various shapes in thick metal plate. The tool attaches to an acetylene cutting torch for such applications as cutting holes through metal walls for pipe and electrical conduit. Squares, rectangles and odd-shaped holes and solid figures can also be formed for metal fabrication, says manufacturer, and because of this tool's small size, it works in confined spaces. Ideas, Inc.

11—PACKAGED CONTROLS for pipeline automation

Consisting of three basic control panels, this "packaged automation" ranges from a simple engine start system to a fully automatic engine and compressor control for remote location. With addition of a computer controller and telemetering equipment, any number of remote automatic panels can be tied together for the automation of a complete station or pipeline. Instrumentation is matched to equipment it regulates, with the control packages becoming more automatic and more complex according to functions automated.

Model SE (sequenced engine control), positioned adjacent to compressor, enables operator to start or stop the engine with the push of a single button. Functions are sequenced electrically in an automatic cycle. Model SEC (sequenced engine and compressor control) combines functions of engine and compressor control in one panel. Located at the compressor, it is designed to monitor and automatically control all operating phases from start to stop. Indicator lights are standard equipment. Model SEC-R (fully automatic control for remote location) can be at a central point away from the individual compressor. Proper operation of compressor and engine are electrically sequenced. Unit has facilities for tie-in to computer control. Clark Bros. Co.

12—HAND CREAM sprays on to form "protective glove"

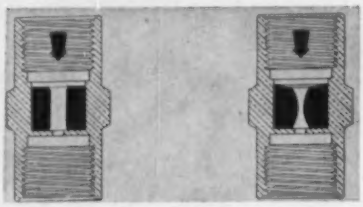
Made with lanolin and glycerine, Protex-A-Hand comes in an aerosol can in foam cream form. You spray it on and rub it in. Application before starting work is claimed to seal out dirt, grease, solvents, paints, chemicals, oils, etc. At the end of a work period it can be washed off, along with accumulated grease and grime. Protection lasts about 4 hrs, it is stated and regular use tends to heal rough hands. Protex-A-Hand is supplied in two sizes, the larger can containing about 225 applications. Acrolite Products, Inc.

13—DRAFTING MACHINE is compact, portable

Draftette Senior No. 12 retains all the advantages of its popular smaller predecessor, folds like a jackknife to fit into a briefcase and can be opened to attach to its drawing board, a desk or table in seconds. It is constructed of aluminum, black anodized, and features a one-piece 6-by-9 in. interchangeable scale with specially processed white numerals which cannot rub off. It is divided into 16ths or 10/50ths, with a 360-deg protractor. With a 20-by-26 in. drawing board, it features 400 sq in. of drawing surface. David Miller & Associates.

14—FLOW REGULATORS, self-cleaning, in eight sizes

Available in eight sizes from 2 through 8 gpm, these flow regulators have brass bodies tapped ½ in. for sizes through 4 gpm and ¾ in. for the larger sizes. Control is obtained by the change in



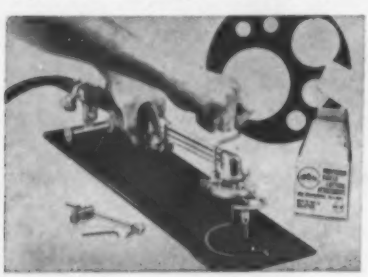
size and shape of the orifice in the rubber member, as indicated in the illustrations. Flow control under minimum inlet pressure is shown at left; under high inlet pressure, at right. The orifice is self-cleaning by the continual flexing of the rubber member. Manufacturer says the regulators are accurate to ± 10 per cent of rated size when used within the range of 20 to 125 psi and suitable for temperatures to 160 F. Taco Heaters, Inc.

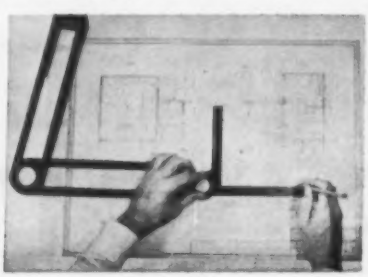
15—TAB ALUMINA CASTABLE is strong, long lasting

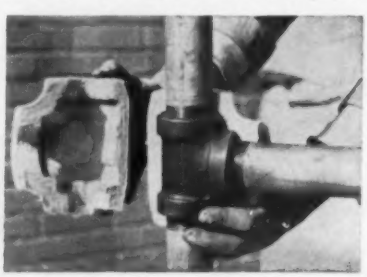
Exceptional crushing and rupture strength are reported for Hydrecon TabCast. According to manufacturer, it is the strongest known tab-alumina castable and the first in the 3500 F range, and will outlast other known castables of its type. Crushing strength of 10,800 psi at 1500 F and 11,200 psi at 2500 F are announced for it. Its low iron content — less than 1/10 of 1 per cent — makes Hydrecon TabCast an excellent castable where carbon and reducing atmospheres or effects from high sulfur oils and other detrimental fuel conditions would make many castables impractical, it is pointed out. It has an alumina content of 93.66 per cent. It comes in dry form and after mixing with water may be poured or cast. J. H. France Refractories Co.

16—PIPE-FITTING INSULATORS slip on easily, look neat

Of molded Fiberglas, I-C Insul-Sure Insulators are said to offer ease of installation, insulating efficiency, neat appearance, immunity to rust, rot and corrosion. They are also claimed to result in net cost savings, compared to conventional methods. To install, you simply place the two halves of the insulator over pipe fitting and then staple, wire or tape the sections together. The insulators are not affected by moisture, it is noted, and are suitable for operat-

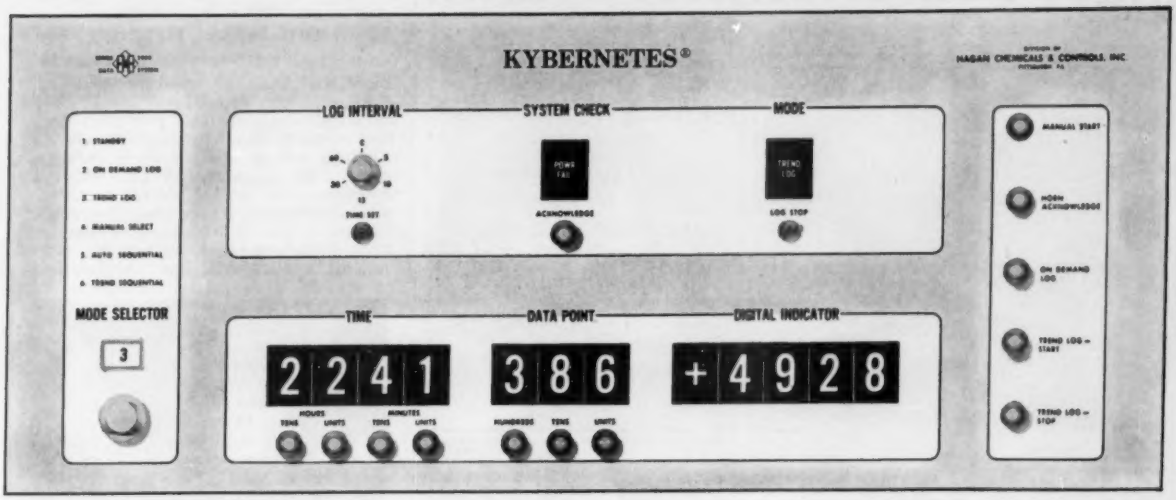






Hagan Chemicals & Controls, Inc., announces the

COMPLETELY NEW



Kybernetes Series 2000 Data Processing System

The new Kybernetes Series 2000 Data Processing System, utilizing solid state components, adds many data handling advances to the outstanding features of the original equipment. Here are some of the features the new Kybernetes system has to offer:

NEW FLEXIBILITY—Basic unit is a simple logging unit for recording process data on a log sheet or other output device. This basic system can be expanded easily, both in terms of the number of points scanned, and the complexity of the operations performed by the unit. For example these can be added as need develops: *Scanning for off-normal conditions—Printed or visual trend of selected variables—Computing and integrating—Automatic programming and optimum setting of control.*

NOTE—*Any* or *all* of these functions may be performed without interrupting any of the other functions. Off-normal scanning *always* proceeds uninterrupted.

OPTIMUM RELIABILITY—Fewer components, simplified design logic and solid state components add to the inherent reliability of the system. All parts have been selected for long life and easy maintenance.

MODULAR CONSTRUCTION simplifies extension of system. Each new function can be added by simply plugging-in appropriate module.

SELF-CHECKING CIRCUITS immediately signal malfunction in any area and spot the area with a warning light.

ACCURACY of 0.1% on all inputs, including non-linear types is achieved by eliminating marginal techniques and components, using the highest quality components and by the use of simplified design logic.

Flexible, accurate and reliable, the new Kybernetes Series 2000 Data Processing System offers many previously unattainable advantages. Designed for maximum usefulness with minimum investment, *the new Kybernetes system permits the addition of functions as needed, including complete computer control.* A new brochure describes these advantages in detail. Write today for your copy; ask for Bulletin MSP-161.

HAGAN CHEMICALS & CONTROLS, INC.

DIVISIONS: CALGON COMPANY, HALL LABORATORIES

HAGAN BUILDING, PITTSBURGH 30, PA.

In Canada: Hagan Corporation (Canada) Limited, Toronto

European Division: Via Fiumendosa No. 13, Milano, Italy

For more data circle 548 on Post Card

DIELECTRIC TEST EQUIPMENT by BIDDLE

...for d-c tests at voltages up to 100 KV

IMPORTANT FEATURES

- Well-designed provisions for utmost safety
- Simple operation and reliable performance
- Excellent output voltage regulation
- Compact, mobile design
- Facilities for voltage and leakage current measurements

IMPORTANT USES

Development—to test d-c dielectric strength of insulating materials and the adequacy of the electric design of insulation in equipment.

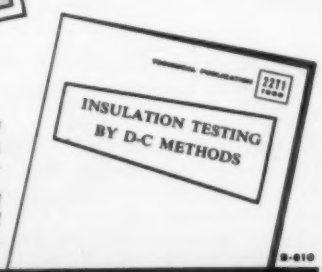
Production—for non-destructively detecting defects in electrical insulation.

Maintenance—and preventive maintenance—for non-destructively detecting unreliable condition of electrical insulation in new or repaired equipment.

NEW TECHNICAL BOOK

A new technical treatise by E. B. Curdts, Director of Engineering, James G. Biddle Co., contains a wealth of pertinent data for the engineer interested in insulation maintenance of electrical equipment.

Copies are available at $2.00 each. Orders should be made on your company's letterhead accompanied by check to the order of the James G. Biddle Co. Ask for Publication 2271PE.



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ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
LABORATORY & SCIENTIFIC EQUIPMENT

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ing temperatures to 450 F. They are available 1 in. thick for ½- to 8-in. screwed fittings, 2- to 8-in. welded fittings; or 1½ in. thick for ¾- to 8-in. screwed, 2- to 12-in. welded ones. Insul-Coustic Crop.

17—LIGHT-WALL FITTINGS for non-critical piping use

Light-wall stainless steel fittings and flanges in the Pipe-Mate line are for nominal-temperature, low-pressure, non-critical process piping. Pipe-Mate Fittings will be stocked in ½-through 4-in. sizes, Schedule 5S and 10S, in stainless steel grades suited to corrosive applications in the area of roughly 150 psi or less, it is announced. Besides providing lower-cost fittings for non-critical applications, the line features

long tangents that permit easy alignment of fittings and pipe and allow clearance for fabrication of completely flanged elbows, returns, tees and crosses. A feature of the line is a swivel-type carbon steel insert flange having a stainless steel insert at the bore into which pipe or fitting can be expanded. Then the carbon steel portion is simply rotated to line up the bolt holes and tightened. No welding is involved. Another feature is a reversible fitting called Plug-R-Cap. Butt welded in regular position it is a cap; reversed it can be fillet welded to act as a plug or pipe closure. Pipe-Mate Fittings can be butt welded or, with the use of an alignment connector or sleeve they can be fillet welded or brazed. Tube Turns Div., Chemetron Corp.

18—FEEDER SYSTEM treats air conditioning cooling water

Designed for continuous, automatic proportioning of liquid chemicals in the treatment of cooling tower water, the Automatic Micro Feeder eliminates need for daily charging of chemicals. It supplies 1/10 to 1 gal of filtered liquid chemical into the circulating water every 24 hr. Manufacturer says that one or two 55-gal drums of chemical can last a season under normal conditions. According to company, this feeder is easy to install, and the control is easy to set and regulate. There is no valving to set and has no moving parts.

Heart of the equipment is an aspirator type chemical feeder with a differential pressure regulator maintaining a constant pressure drop across a porous stone that acts as a rate valve. The chemical feeder is connected by plastic tubing to suction and discharge lines of the cooling tower water circulating pump. Differential pressure, averaging 20 to 40 lb, creates a vacuum in the

The plant that never shuts down can't take a chance on Steam Traps

by John W. Ritter, Test Engineer
SARCO Company, Inc.

It pays to take a careful look at the economics of the whole problem of steam trapping. This is particularly true where a plant is operating continuously.

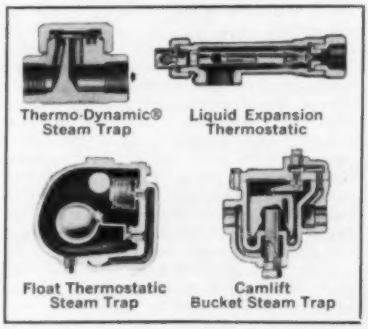
Twenty-four hour, 7-day production can be a mixed blessing. There is a great satisfaction in working to full capacity, but it doesn't leave much time to keep the equipment in first class working order. If major repairs or replacements become necessary, the partial shut-down that results can disorganize the whole output schedule.

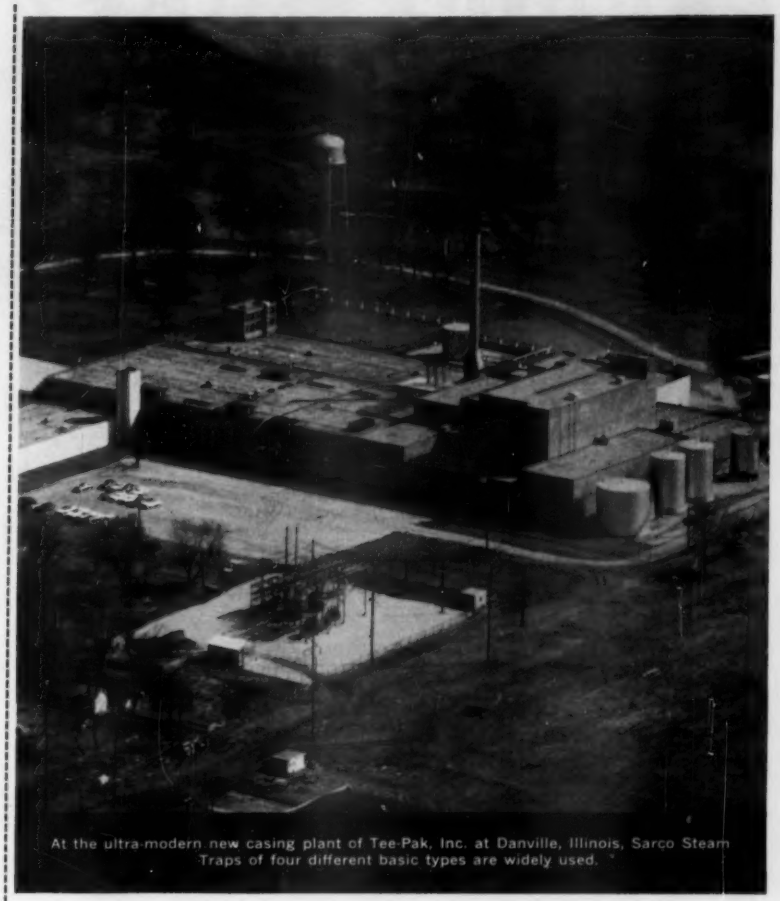
Some steam traps are much easier to maintain than others, and it pays to look into this easy maintenance feature of traps as carefully as you examine their operating characteristics.

Another important point in steam trap selection is to be sure the right trap is chosen for each job. Plant engineers know the operating conditions and if new questions arise on which they want supplemental consultation, they can have their questions answered without cost or obligation by a group of men who have real depth and breadth of experience in *production planned* steam trapping — Sarco engineers. Sarco advice is always impartial advice, because Sarco makes all five types of steam traps.

Sarco engineers, for example, can demonstrate the economy of the Sarco TD-50, which is as near maintenance-free as a steam trap can be. They can show the special values of the Sarco Thermostatic, which requires no adjustment over a 300 psi operating range. There are any number of uses for the continuous discharge of the Sarco Float-Thermostatic particularly when closely controlled temperature must be maintained.

For every steam trapping need there is one best steam trap, ideal in its operating functions and built for an absolute minimum of required service and maintenance. Studying your individual plant needs in steam trapping, and filling these needs with the traps best suited to do their respective jobs will pay out handsomely in your production and operating records.





At the ultra-modern new casing plant of Tee-Pak, Inc. at Danville, Illinois, Sarco Steam Traps of four different basic types are widely used.

At Tee-Pak's new casing plant they depend on SARCO Steam Traps to help prevent down-time

Twenty-four hours a day — seven days a week. That's the operating schedule at the modern new Danville, Illinois, plant where Tee-Pak produces its cellulose casings. Requiring dependable operation from all equipment, the company has used four different types of Sarco Steam Traps, each selected to do a reliable, trouble-free job in its particular application.

When you have a steam trapping problem, whether it's a single installation or dozens of different applications, consult your local Sarco representative or write Sarco directly for impartial advice on *Production Planned* steam trapping, because . . . 7945

SARCO
COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Only Sarco makes all 5 types:
Thermo-Dynamic • Thermostatic • Liquid Expansion
Float Thermostatic • Bucket

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

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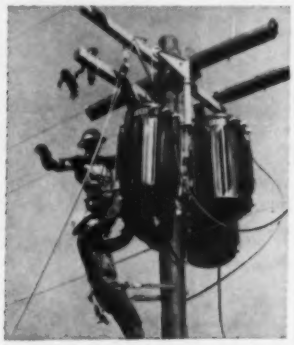
reagent side of the unit that induces reagent flow from the supply drum into the container through the porous stone, through the differential pressure regulator and then into the main stream at the aspirator. Flow rate through the stone depends on depth of its immersion in the transparent bowl. A push button control lets air enter or escape and thus regulates reagent level in the bowl. The unit is suggested for cooling towers of 10 to 400 tons capacity in normal use. The Bird Archer Co.

19—TRANSFORMER HOIST has increased safety factor

The MoPeCo Transformer Hoist has a redesigned base clamp with increased strength and support to increase the safety factor for workmen on utility poles. The two-piece unit is raised by a hand line and assembled at the top of the pole. The base clamps to the pole



by means of chains and a simple clamp. The cable of manila rope from the truck winch passes up through the base assembly and over the sheaves, utilizing the power from the truck to raise the transformers. Rear sheave has been dropped two inches to prevent slippage or bind hazard. Aluminum sheaves have been designed for steel cable or manila rope. Morrison-Pelsue Co.

20—COOLING TOWERS with improved filling support method

Now standard equipment in this company's industrial cross-flow cooling towers is a new method of supporting filling splash bars. The filling is supported by molded grids fabricated of glass fiber reinforced polyester resin, which is non-corrosive and immune to rot and decay. Besides increasing tower service life and reducing maintenance cost, these supports are said to provide a permanently level splash bar installation that prevents water channeling; to assure a precisely engineered splash bar arrangement for maximum water breakup, and to minimize restriction to air flow. Although of light weight, the design and materials in the grid supports are said to provide a safety factor of 30 to 1. The Marley Co.

21—CONTROLLED VOLUME PUMP for hard-to-handle solutions

The O.D.S. Controlled Volume Pump utilizes design principles of the Oliver Diaphragm Slurry Pump (Dorr-Oliver Inc.), long in use for moving corrosive and heavily concentrated slurries. Since

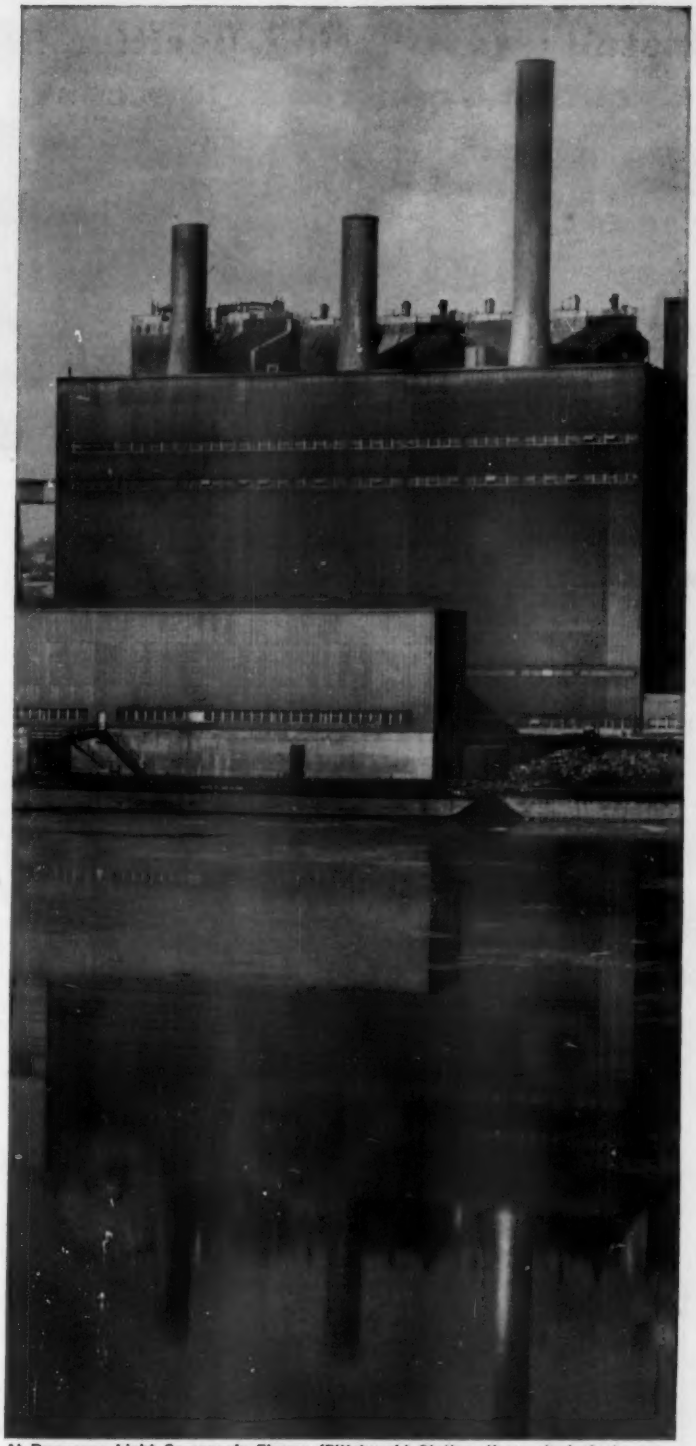
Lengthen stack life with corrosion-resistant concrete

Corrosion-resistant concrete linings, made with Lumnite calcium-aluminate cement and Haydite aggregate, will protect stacks and breechings from the corrosive action of condensate.

Such linings also provide insulation to keep stack gases hot, helping to maintain better draft for greater operating efficiency. The steel shell will be kept cooler, extending life of exterior paints. In addition, monolithic concrete linings have a lower unit weight, reducing the dead load on the supporting structure. Installation is easy, economical – by guniting or plastering. Concrete will reach service strength in 24 hours, reducing outage time.

For convenience, manufacturers of refractories offer castables bonded with Lumnite cement – packaged mixtures ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N.Y.

"USS," "Atlas" and "Lumnite" are registered trademarks



At Duquesne Light Company's Elrama (Pittsburgh) Station, these steel stacks are being extended and then lined with corrosion-resistant concrete, made with Lumnite cement.

Universal Atlas Cement
Division of
United States Steel

L-198

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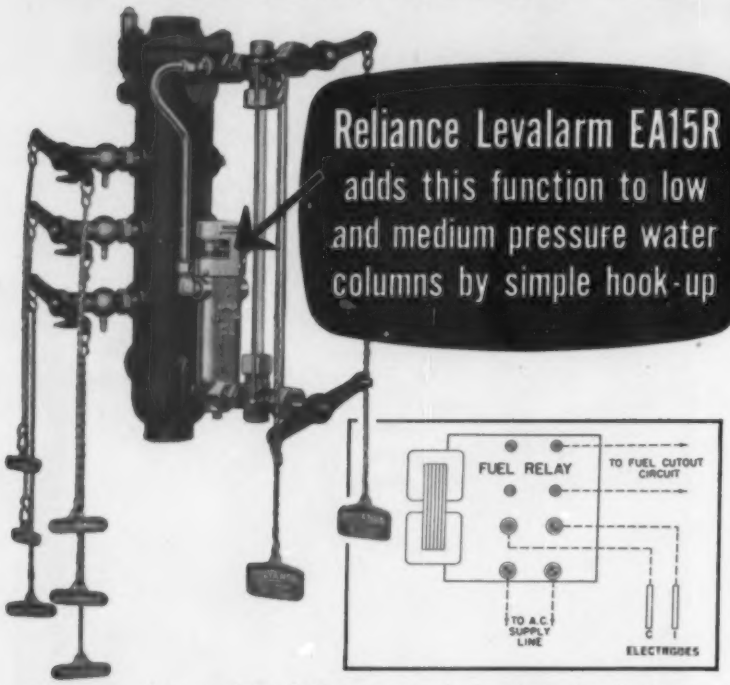
Install a fast-acting, positive fuel cut-out control at low cost


Reliance Levalarm EA15R
adds this function to low and medium pressure water columns by simple hook-up
FUEL RELAY
TO FUEL CUTOUT CIRCUIT
TO A.C. SUPPLY LINE
ELECTRODES

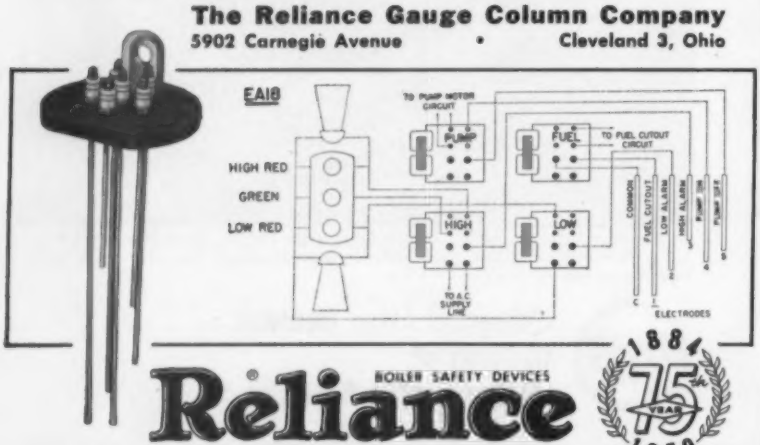
Two electrodes extend into boiler water in the Levalarm chamber. Water surrounding them completes a closed circuit carrying special current supply from a transformer. When water level drops below the electrodes, the relay circuit to the solenoid-operated fuel valve is broken. Action is immediate. An auxiliary alarm can be actuated at the same time. This Levalarm may be installed on any water column having gage centers not less than 12½"; maximum 450 psi. Very easy to install . . . Another model is designed for pressures to 900 psi.

Up to FIVE functions possible with other Levalarms

Broad protection for your boiler's safety can be realized through multiple-electrode Levalarm models that install in the water column cap. Model EA18 has enough electrodes to provide fuel cut-out, low and high water alarms, and start and stop feed pump. To comply with insurance company rulings requiring dual fuel cut-out facilities, an extra electrode can be added to the Levalarm. Thus no additional piping needed.

It will pay you to get details on Reliance Levalarms. Write for Bulletin D2 or contact nearest Reliance Representative.

The Reliance Gauge Column Company
5902 Carnegie Avenue • Cleveland 3, Ohio



BOILER SAFETY DEVICES
Reliance

1881 75 YEARS 1959

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the latter is designed as a transfer pump, manufacturer of this new unit has effected modifications to obtain controlled volume pumping, including inclination of pump chamber to eliminate entrained air from the body. Also, to obtain highest slurry metering accuracy, the modified design has double ball checks.

Tests are reported to show this new pump can handle slurries containing up to 60 per cent solids and deliver them at pressures to 90 psi. It consists of two hemispheres clamped together with a slack diaphragm between. The lower hemisphere has inlet and outlet check valves; the upper one is connected to an air supply by a three-way solenoid valve which alternately pressurizes and exhausts the chamber. A timer electrically operates the three-way valve. When upper hemisphere is exhausted, suction pressure forces liquid into lower hemisphere through the suction ball check, displacing the diaphragm upward. When upper hemisphere fills, it is pressurized, and downward movement of the diaphragm forces liquid from lower hemisphere through discharge ball checks. By adjusting the timing mechanism you can vary flow volume from 0 to 180 gph. Stroke length is regulated by an electrical probe mechanism. Milton Roy Co.

22—PIPE WRENCH works with compounded leverage

One man can do the work of two — and two can do the work of four, according to manufacturer — with the Ridgid Compound Leverage Wrench. Pressure applied on the malleable handle is multiplied by two as the adjustable hook jaw turns the pipe in one direction, while the offset chain vise head grips

the fitting and exerts an equal pressure in the opposite direction. By slipping the removable chain vise head into place on the desired side of the handle, wrench can be used to tighten or loosen right or left hand threads, with pipe on either side of fitting. Wrenches are available in four sizes for 2- to 8-in. pipe. The Ridge Tool Co.

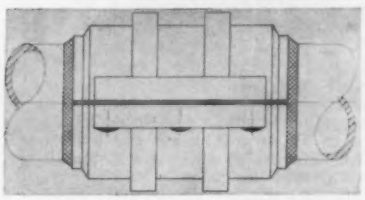
23—SILICONE GREASE is rust inhibitant and lubricant

For mated, threaded or non-threaded ferrous components and fabricated rubber parts, Compound SS-4007 is said to maintain its consistency from −75 to 300 F, and to be serviceable in many applications where other products would solidify or be subject to oxidation,

evaporation or excessive bleed losses. Primary applications include use as a high and low temperature thread lubricant, corrosion preventive compound, and rubber lubricant for low and medium swelling components such as O-rings. Among benefits reported is corrosion protection — SS-4007 is chemically inert, and protects metals against air oxidation. After 70 hr at 212 F in air, no pitting or corrosion occurs on brass, cadmium plated steel, zinc, magnesium, aluminum and steel coated with SS-4007, manufacturer states, and even salt water will not corrode steel protected by a coating of this compound. It is also said to offer good storage stability and ease of application. It can be brushed, wiped or sprayed on. General Electric Co.

24—COUPLING can also function as sleeve, pipe repair clamp

Split longitudinally, the versatile Smith Split-Coupling can be used as coupling, split sleeve or pipe repair clamp. Clamping means are provided to resist endwise pull of the pipe when it is used as



a coupling. The unit is all steel and can be welded — while pipeline is in service — to become an integral part of the pipeline. It is welded to the pipe by full encirclement welds. Only assembly work required in the field is placing the two halves of the Smith Split-Coupling around the pipe and tightening the side bolts. Sizes will be 2 through 4 in. The Pipe Line Development Co.

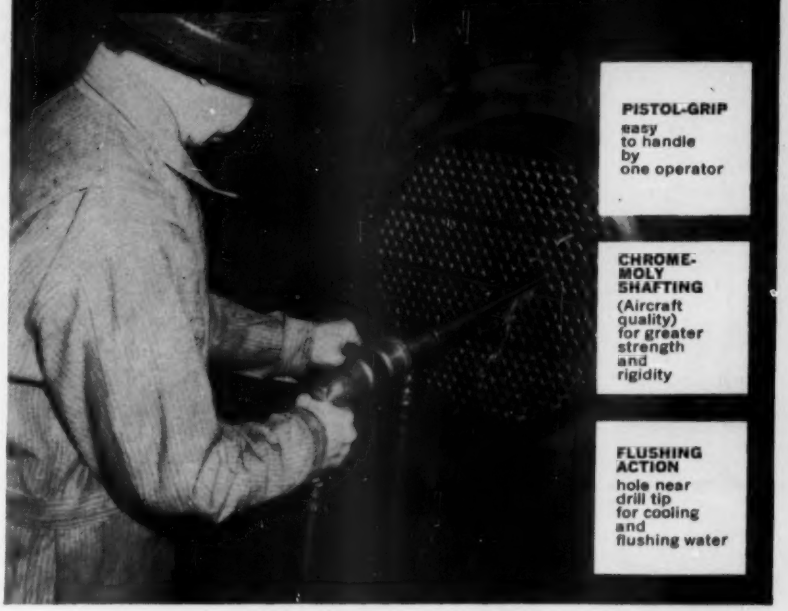
Reader Service Cards on pages 125–126 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

25—PACKAGED BOILERS in 400-, 500-, 600-hp sizes

These additions to manufacturer's CB line of packaged fire tube boilers are suggested for heating and processing steam or hot water for larger commercial, industrial and institutional applications. They are available for high or low pressure steam and can be fired with oil, gas or combination oil/gas. Features announced include four-pass forced draft construction for high flue gas velocity, high efficiency and less tube cleaning; davited doors; rotary air damper for smooth air modulation without vibration or noise; fully automatic operation with safety controls covering the full firing range. A single motor runs caseless fan and air compressor for low pressure air atomizing burner. Low cost gas conversion is announced — oil-fired models have gas

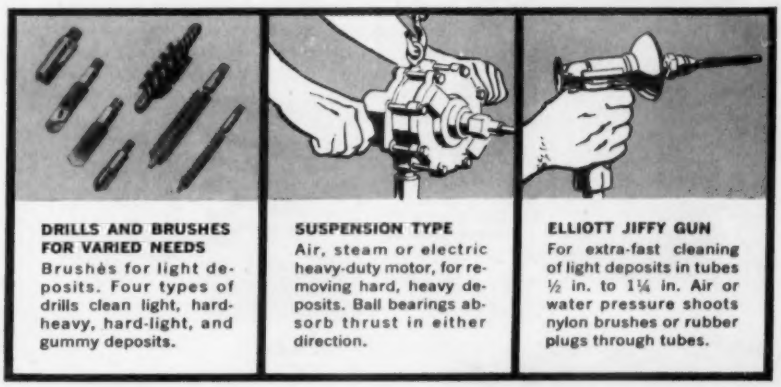
newest ELLIOTT tube cleaner

lightweight! air-driven!


PISTOL-GRIP
easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
FLUSHING ACTION
hole near drill tip for cooling and flushing water

for condenser and heat exchanger tubes

Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.



DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.

SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.

ELLIOTT JIFFY GUN
For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

ELLIOTT Company
Lagonda Plant—Springfield, Ohio

Y9-1

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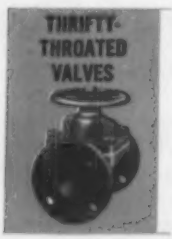
"WAM" PUMP
Highest pumping efficiency, with faultless corrosion resistance. Hard rubber casing and impeller; Hastelloy C shaft. 80 gpm. Bul. CE-55.


THRIFTY-THROATED VALVES
Liquids never touch metal in Ace diaphragm valves! Rubber or plastic-lined cast iron, or solid plastic bodies. Sizes ½ to 6". Ask for facts.

ACE-ITE
all-purpose tough
High-impact, rubber-plastic, most economical for average chemicals. ½ to 6". Screw or solvent welded fittings. Valves ½ to 2". NSF-approved. Bul. 80A.

Still bothered by corrosion?

Downtime, ruined equipment, endless repairs are more than disturbing... they're expensive too. You can put an end to 85 to 100% of your corrosion and contamination losses by specifying chemical-resistant Ace rubber and plastic equipment... pipe, valves, tanks, pumps. American Hard Rubber Company's 108 years of experience is ready to help you with any problem.

RIVICLOR
ageless strength
All-purpose rigid PVC. Sched. 40, 80 & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". NSF-approved. Free Bul. CE-56.

ACE processing equipment of rubber and plastics

AMERICAN HARD RUBBER COMPANY
DIVISION OF AMERACE CORPORATION
Ace Road • Butler, New Jersey

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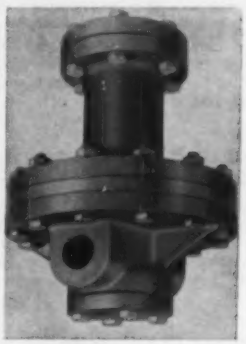
burner rings and tappings. Unified electric and steam oil preheater reduces piping and radiant heat loss. Each unit is blanketed with fiber glass insulation, metal jacketing. Cleaver-Brooks Co.

26—REGULATING VALVES control atomizing steam pressure

Two differential pressure regulators for steam service include the Fig. 1200, Type C, which controls atomizing steam pressure at an adjusted value higher



than fuel oil pressure, and the Fig. 1210, Type C, which controls it at an adjusted value lower than the fuel oil pressure (not pictured). These valves come in ¼- to 2-in. sizes and are described as easy to service and install. Of shear port design with honed guide, the regulators have telltale ports which indicate rupture of either steam or oil diaphragm. O-ring seals are suitable for 400 F. Range of differential pressure adjustment is 5 to 45 psi. Atlas Valve Co.

27—CIRCULAR SLIDE RULE is small and easily used

Operation of this handy, pocket-size circular slide rule is fast and simple, company states, and the results are accurate. You can use it to multiply,

divide and find proportions — instructions are included. The slide rule is available without charge to qualified power engineers. General Industrial Co.

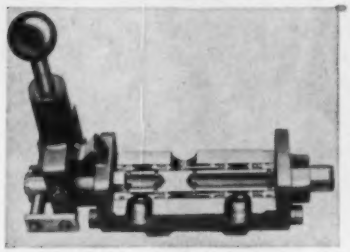
28—DUCT FANS feature speed adjustment, standardization

Variable pitch drives which permit quick adjustment of fan speed — and thus of fan noise and air volume — are standard equipment on this redesigned line of belt-drive duct fans. Simple adjustment of the driver sheave slows

the fan to reduce air deliveries by up to a third where maximum catalog performance is not required. A second feature is complete standardization of components within each fan size. This means that a change of motors to meet changing air delivery needs requires no modification of the fan and can be made while the fan is still in place in the duct work. Sizes are from 12 to 60 in. Bulletin A-114A gives details. Hartzell Propeller Fan Co.

29—HYDRAULIC VALVES are single piston type

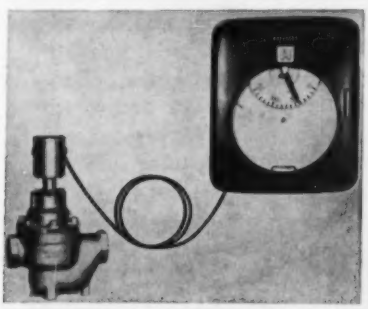
Unique feature of Durable Seal Valves, as reported by manufacturer of these single piston hydraulic operating units, is that the same line pressure acts both inside and outside the U-cup seals at all times during the operating cycle. Thus



seals are floated across ports without distortion, shear or undue wear, it is noted, and there is no distortion of the stainless steel piston or of the pedestals which position the U-cup seals. The result is claimed to be low upkeep, long valve life, positive control and easy operation. Available in sizes from ½ to 2 in., in three- and four-way types, and up to 6 in. in the two-way or spray valve type, Durable Seal Valves have screwed or flanged pipe connections, for direct hand operation or a variety of remote controls. They are cast in bronze or steel for working pressures to 2000 lb. Reference Book 39-6 gives details on the valves. Homestead Valve Mfg. Co.

30—REMOTE-MOUNTED METER indicates, records boiler feed

This remote-mounted boiler meter is described as an accurate and inexpensive means of indicating and recording total feed to boiler and giving a permanent record of boiler output. With



this meter, daily feed loads may be read on a continuous integrating recorder, the instantaneous load may be quickly checked on the visual Flowrator, and peak load permanently recorded on 24-hr chart. The Henszey Co.

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two new INTERCHANGEABLE trays for support of cables, wiring and tubing

★ Engineered for uniform design and easy installation
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Now, for the first time, two types of cable trays, one a ladder type and the other a basket type, are available to be used INTERCHANGEABLY at any given location, depending on the type and weight of the cables to be suspended. The advantages of each type tray can thus be used to the fullest extent. Globetray, the ladder type, is intended for use where festooning is not a problem, while Cable-Strut, the basket type, is intended for the support of communication wire, instrument tubing and control cables in automation applications.

These two cable trays have been thoroughly field tested in hundreds of large industrial installations, in new plant construction, in power plants, in modernization, and for power distribution in all types of manufacturing processes. A new catalog, just off the press, gives full information and installation techniques. Ask for your FREE copy today.

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LUBRICATION

201 Organized Lubrication — Benefits of organized lubrication are extolled in this 24-pp bulletin. Cost control opportunities are detailed and the task of assigning responsibilities and delegating authority in an organized lubrication system discussed. Method of determining savings and setting up records to measure results is also covered. The Texas Co.

202 Versatile Industrial Oil — Described in 20-pp Form AD 4078 is an all-purpose oil offering protection for a wide range of industrial equipment, and available in 15 viscosity grades. Discusses six major characteristics of the oil; explains and pictures its use in hydraulic systems, speed reducers, air compressors, electric motors, hydraulic turbines, bearing systems, etc. A chart shows grades available, uses, properties. Standard Oil Co. (Ind.)

WATER CONDITIONING

203 Boiler Water Treatment — Chemical reduction of oxygen in boiler feedwater with hydrazine is the subject of 10-pp Bulletin BW. Economy and operation, handling of the Deoxy-Sol, methods of analysis and other details are covered. A bibliography lists supplementary reading. Fairmont Chemical Co., Inc.

204 Coagulant Aids — Featured in this product bulletin is a line of coagulant aids designed to improve floc formation in clarifying and softening water. Advantages are detailed and typical applications described. Calgon Co., Div., Hagan Chemicals & Controls, Inc.

205 Consulting Service — Advantages of company's consulting service are detailed in 8-pp Bulletin 5006-A. How the service is qualified to solve problems concerning scale and corrosion control in boilers, cooling systems, and process waters is discussed. Dearborn Chemical Co.

206 pH and Chlorine Control — The 14th, 1959 edition of company's handbook, "Modern pH and Chlorine Control," 100-pp, incorporating theory and practice of colorimetric analysis, serves as a reference for quantitative determination of pH, chlorine, phosphate, nitrate, sulfate, hardness and other tests. Slide comparators and complete test kits are illustrated. In addition to standard pH determinations, methods are outlined for quantitative analyses of phosphate, calcium magnesium, silica, nitrate, hardness. Available to qualified power engineers, please state your job title. W. A. Taylor Co.

207 Feedwater Heaters—Open-Coil, tray-type feedwater heaters and purifiers of both deaerating and nondeaerating type are presented in 12-pp Bulletin 117-A. Construction and operational features of the heaters are explained and illustrated,

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and more than a dozen available models are pictured along with application suggestions. Stickle Steam Specialties Co.

208 **Deaerating Heaters** — Twelve-pp Bulletin WC-106A on tray type deaerating heaters covers principles of deaeration, tray heater operation, standard heater design and applications, accessory equipment, and design and fabrication of tray utility heaters. A section on design features discusses load variations, installation, metallurgy and construction of trays. Graver Water Conditioning Co.

PUMPS, COMPRESSORS

209 **Low Pressure Compressors** — Eight-pp Bulletin A-95 describes a line of low pressure compressors for heavy duty industrial applications. Engineering design features are detailed and advantages explained. Joy Mfg. Co.

210 **For Abusive Pumping Jobs** — This Pump Selector covers centrifugal pumps for wide industrial use and especially adapted to handling ashes, abrasive mixtures, slurries, hot and corrosive liquids. It describes several basic types: a horizontal shaft, single-stage side suction pump; a horizontal shaft, single-stage, rear-entrance automatic priming pump; vertical shaft pumps. Nagle Pumps.

211 **Controlled Volume Pumps** — Bulletin 258 describes Milroyal controlled volume pumps with totally enclosed drives. Discusses design features of the pumps and tells how they work. Also gives specifications. These pumps are designed for metering of chemicals against pressures to 1900 psi in adverse atmospheres. Milton Roy Co.

212 **Proportioning Pumps** — Catalog 604, 8 pp, covers details and specifications of two mechanical and hydraulic drive metering and proportioning pumps, for precision pumping as low as 11 cc per min, and a chemical pump for systems requiring limited capacities. Advantages are given. Hills-McCanna Co.

PACKINGS, GASKETS

213 **Mechanical Packings** — Catalog P-210C contains 40 pp of detailed information on company's line of mechanical packings and gasket materials. It contains illustrations, descriptions, complete service recommendations and specification charts. Raybestos-Manhattan, Inc.

214 **Gaskets and O-Rings** — Gaskets, back-up rings and O-rings impervious to acids, alkalis, corrosives and solvents at temperatures from −120 to 500 F are described in 6-pp Bulletin P-327. Information includes service and mechanical recommendations, data on operating pressures and standard sizes. Crane Packing Co.

INSTRUMENTS, CONTROLS

215 **Gages, Needle Valves** — Catalog 76-G consists of a loose-leaf bound collection of literature on gages and needle valves. Various types of gages are illustrated and described, with applications and specifications fully detailed. A section covers accessories. Jas. P. Marsh Corp.

216 **Instruments and Controls** — Catalog 57-6 describes instruments and controls, including flow meters, liquid level

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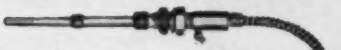

Tru-Lay Push-Pull Controls provide POSITIVE REMOTE-ACTION over long or short distances . . . with fixed or movable anchorages . . . for light loads or loads up to 1,000 lbs., and these units are frequently and successfully used in conjunction with Electric, Hydraulic and Air Controls.

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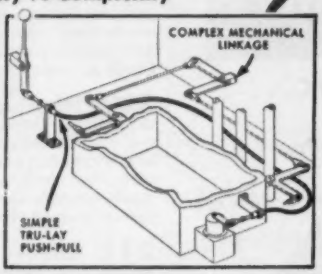

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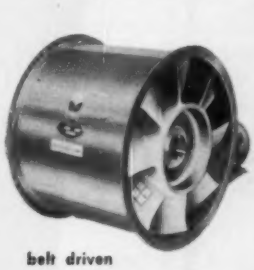

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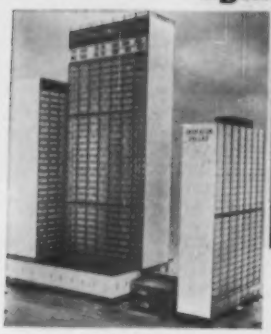

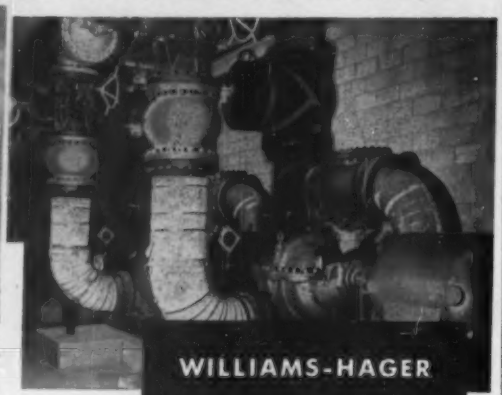

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or pressure gage, CO_2 meters, boiler meters, pneumatic transmitters, strip chart recorder, pressure, vacuum and differential recorders, temperature recorder, multipoint gages and others. Includes descriptive data. Republic Flow Meters Co.

217 Resistance Temperature Detectors — In 8-pp Publication 3016D are described a line of remote temperature-sensitive elements for use in indicating, recording, controlling and monitoring equipment. Operations, application and construction details of the resistance temperature detectors are presented. Instrument Div., Thomas A. Edison, Inc.

218 Ion-Exchange Controls — Bulletin E-158 describes automatic control systems for ion-exchange equipment. Standards designed to assure proper performance of control units are detailed, and various elements in the control cabinets, as well as the power-operated units, are described. Specifications for electrical controls are also included. Illinois Water Treatment Co.

219 Ideas on Push-Pull Controls — Included in this "Idea File" are answers to a power engineer's questions on the use of push-pull controls. A general information booklet discusses remote control applications, explains construction and operation of company's Tru-Lay controls. Separate bulletins are devoted to standard assemblies, bracket-type head controls. Automotive and Aircraft Div., American Chain & Cable Co., Inc.

220 Metering, Control Systems — Bulletin 500 describes purpose, design and operation of company's metering and control systems. Includes discussion of pneumatic and electric telemetering and pneumatic control, along with detailed literature references. Bailey Meter Co.

221 Guide to Gages—Catalog 300-B, 112 pp, features Ashcroft, Duragauges, Maxisafe, pneumatic receiver, recording, quality, drawn case, chemical and special application gages. Also presented are gage testers, pneumatic transmitters, gages for nuclear energy. Engineering data and charts are provided. Instruments shown cover dial sizes from 2 through 24 in. Manning, Maxwell & Moore, Inc.

222 Water Columns, Gages — Brochure AO describes water columns, gages and equipment for the low-pressure range (0 to 250 psi). Explains principles and construction of low pressure alarm water columns, and lists accessory equipment. Reliance Gauge Column Co.

BOILERS, GENERATORS

223 Fire Tube Boilers — This 12-pp catalog describes Superior Compact packaged boilers in capacities from 20 to 200 bhp. Interesting arrangement of text, illustration and color is used to explain many features. Gives dimensions for boilers designed for firing oil or gas or both. Superior Combustion Industries, Inc.

224 Hot Water Boilers — This 20-pp Brochure HCC-2 describes and illustrates design, construction, advantages and economies of the C-E La Mont controlled circulation hot water boiler for supplying high pressure, high temperature water for heating systems and process uses. Combustion Engineering, Inc.

225 Boilers for Many Services — This general product data catalog in loose-

leaf notebook form contains detailed literature on company's line of boilers for heating, power and process steam. It contains separate data sheets for each product, including high pressure boilers, low pressure boilers, boiler-burner units, water-tube boilers, water heating equipment and others. In addition to photos and diagrams it provides tabulated engineering data. Industrial Div., American-Standard.

226 **Packaged Steam Generator** — Advantages of company's baffleless, pressurized two-drum water tube packaged units are detailed in 12-pp Catalog SB-59. Features of the completely integrated generating plant, which requires no field piping, wiring, brickwork or special foundation, are shown on cutaway illustration. Erie City Iron Works.

227 **Packaged Generators** — Bulletin MH 3-54, 14-pp, gives detailed coverage to company's Type MH packaged water tube steam generators which are furnished for oil or gas firing or both, with automatic, semi-automatic, or manual controls. Included are: cutaway illustrations, installation photos, tube arrangement layouts, construction details, auxiliary equipment, dimensions. Union Iron Works.

228 **Self-Contained Boilers** — Bulletin AD-162, 8 pp, describes company's complete line of self-contained boilers for heating and processing steam or hot water. Design features and advantages are detailed and a cutaway view showing flow of air in the forced draft system is included. Cleaver-Brooks Co.

229 **Steam Generator** — Bulletin F-14 contains 32 pp of detailed information on company's water tube type steam generator. Photos and diagrams illustrating design and construction features are included, as well as a dimension table. E. Keeler Co.

230 **For Low-Pressure Heating** — Guide Specifications GS-1, 58 pp, covers underfeed stoker applications to boilers best suited to commercial and industrial heating plants. Includes drawings of flexible layouts of the equipment, as well as specification criteria covering coal and ash handling, boilers, stokers and controls. Bituminous Coal Institute.

VENTILATING, DUST CONTROL

231 **Air Engineering** — Bulletin E-57 is a 24-pp air engineering data file covering engineering and test facilities for propeller fans, specifications, construction, maintenance, and installation. Tables for estimating air-handling requirements, entrance and elbow losses are provided. Aerovent Fan Co., Inc.

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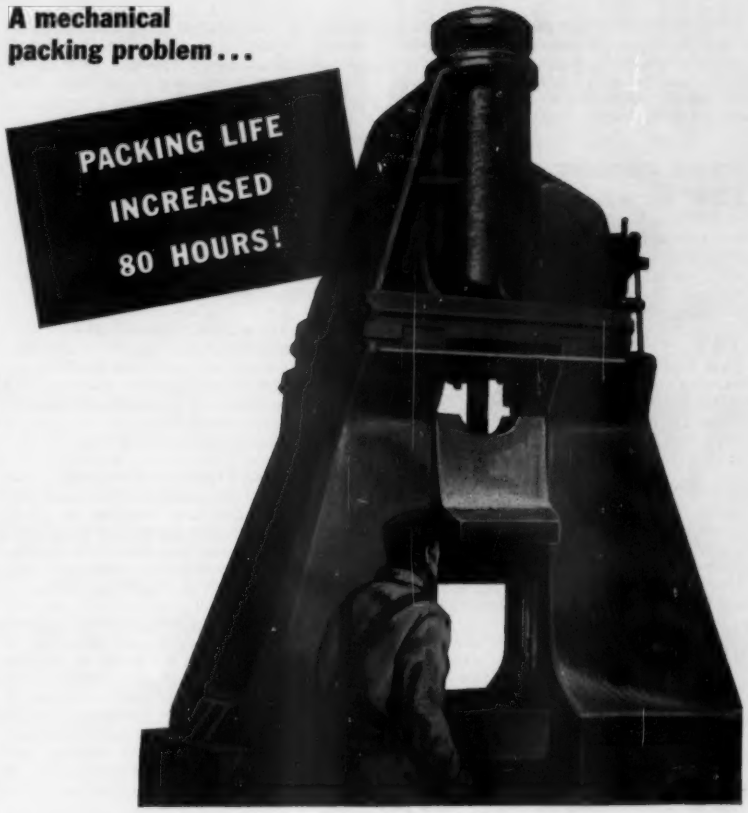
232 **Dust Control System** — Advantages offered by company's Chem-Jet dust control system for coal handling operations are illustrated and described in this 6-pp bulletin. Principle employed in the system is discussed, also equipment required. Chart shows moisture requirements. Johnson-March Corp.

A mechanical packing problem . . .



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The packings on this 3500-lb.-capacity steam hammer formerly lasted about 160 hours. Then, one day, an R/M distributor advised using R/M Vee-Square,® a Big 7 Packing. It was a tremendous success! Packing life is now about 240 hours, very few adjustments are needed, and maintenance costs are way down.

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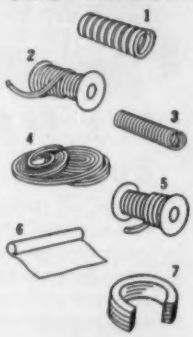

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233 **Ventilation Units**—Bulletin FM-315, 25 pp, describes basic construction of company's package propeller fans for commercial and industrial applications. Illustrated case histories of typical installations are included. Buffalo Forge Co.

FUEL BURNING EQUIPMENT

234 **Oil and Gas Burners** — Bulletin OB-53, 28 pp, gives principles of selection and application of oil or gas burners, or a combination of both for standard and wide capacity range operation, together with air registers and fuel oil heating and pumping sets. The Engineer Co.

235 **For Burning Refuse Fuel** — This 8-pp bulletin describes refuse fuel burning equipment, including a pneumatic refuse fuel distributor which spreads refuse fuels such as bark, wood chips, and bagasse uniformly over the grate surface. Discusses various components. Riley Stoker Corp.

236 **Water-Cooled Stoker** — Design and operating advantages of the Vibragrate Stoker are outlined in this illustrated bulletin. A large cutaway view details component parts of the stoker and explains operating features. Other drawings show installations. American Engineering Co.

237 **Spreader Stoker** — Catalog 860 contains 20 pp of detailed information on company's overthrow rotor type spreader stoker for boilers of medium size up to 60,000 lb steam per hr capacity. Describes features of design and operation and illustrates applications. Detroit Stoker Co.

238 **Dual-Stage Burners** — Bulletin 25 describes an oil burner with two stages of atomization — mechanical and steam. Advantages are fully illustrated and described, and a cutaway view showing component features is included. National Airoil Burner Co., Inc.

COAL AND ASH HANDLING

239 **Shredders, Crushers** — Bulletin 257 describes and illustrates hammermills and shredders, rolling ring and special crushers for reducing chemicals, minerals, ceramics, and other materials including wood waste. Discusses construction features. American Pulverizer Co.

240 **Hydraulic Shakeout** — Bulletin 658 describes and illustrates the Carquake, hydraulically powered car shakeout designed for maximum car shaking with minimum noise. Rail- and stationary-mounted types are shown. Six advantages detailed. Stephens-Adamson Mfg. Co.

241 **Coal Crusher** — Factors to consider in selecting a coal crusher for a particular operation are detailed in 12-pp Bulletin 154. Types of coal crushers and advantages of each are described and capacity and specification data included. Gruendler Crusher & Pulverizer Co.

242 **Bucket Elevators** — Comparison of elevator types and selection of bucket elevators for a variety of applications are covered in 80-pp Catalog be-55. Specifications and dimensions for centrifugal discharge, perfect discharge, continuous bucket, gravity discharge elevator-conveyors, pivoted bucket carrier, bulk cement systems, and marine legs are included, as well as supplementary information. Webster Mfg., Inc.

REFRACTORIES

243 **Refractory Castable** — Bulletin R-40 describes the use of Kaocrete, company's refractory castable, in boiler ashpits. A discussion of the various methods of ash removal, along with the maintenance problems peculiar to each, is presented. Four installations detailed. Refractories Div., The Babcock & Wilcox Co.

244 **Refractory Mortar** — This is a 24-pp manual covering the use of Lumnite calcium-aluminate cement as a mortar mix for gun-applied linings in power plant, refinery and metalworking equipment. Includes data on mortar preparation, placing procedures, curing: also information on use of Lumnite cement as a masonry mortar for laying brick. Universal Atlas Cement Div., United States Steel Corp.

245 **Mastic Cement** — Bulletin 860 describes characteristics and advantages of a mastic cement designed for use in boilers, incinerators, and all types of industrial heating units. Technical and installation data. J. H. France Refractories Co.

TUBING AND ACCESSORIES

246 **Heat Exchanger Tubing**—Cited in 30-pp Catalog A-205 are typical cases where cupro-nickel or Monel tubing installed in heat exchangers resulted in substantial savings and better efficiency through longer tube life. Describes applications of this tubing in various instances where unusual water conditions required it. The International Nickel Co., Inc.

247 **Tubes and Plates** — Publication B-2, 46 pp, covers the subject of tubes and

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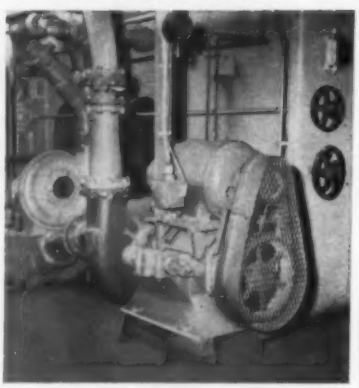

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plates for condensers and heat exchangers. Field of application and particular problems encountered in each are described. Information on condenser tube alloys, plates for tube sheets and baffles, manufacturing methods, installation, operational factors affecting tube life, corrosion factors in condenser tube service is presented. The American Brass Co.

248 Integral Finned Tube—Detailed information on a line of integral finned tube for heat transfer applications is presented in this 24-pp bulletin. Tables list sizes, alloys, heat transfer data, application data and other information essential for the proper selection of integral finned tubing for heat transfer applications. Wolverine Tube, Div., Calumet & Hecla, Inc.

249 Tube Cleaners — Bulletin G-515 describes company's line of air, steam and water driven tube cleaners and accessories. Photos of the various types of cleaners are included, along with descriptive details and specification data. Elliott Co., Roto Plant, Div., Carrier Corp.

250 Tube Expanders — Bulletin Y-49 contains 12 pp of data on tube expanders designed to make a good hydraulic (or pneumatic) and mechanical seal between tube and tube sheet. Dimension and specification tables included. Elliott Co.

INSULATION

251 Foam Insulation — Expanded polystyrene insulation for cold storage applications is featured in this illlustrated bulletin. Method of application is shown, and physical and thermal properties of the material listed. Johns-Manville.

252 Pipe Insulation — This 40-pp catalog was designed as a reference guide to company's pipe insulation, presenting a new way to specify proper thickness for pipe insulation, based in the "J" factor. This special index eliminates complicated computation formerly required to determine economical thicknesses. The book also features detailed drawings that show how single-layer insulation is applied to various vertical and horizontal expansion joints as well as to pipe bends, flanges, fittings. Union Asbestos & Rubber Co.

253 Duct Insulation — Spun mineral wool duct insulation is illustrated and described in Bulletin J-360-A. Advantages are listed and data on thermal conductivity and sound absorption characteristics tabulated. Standard application procedures are described. Baldwin-Hill Co.

254 Mineral Insulation — Properties and characteristics of Gilsulate and its applications as a material for insulation and protection of underground hot pipes and systems are described in this illustrated booklet. Table of specifications is included. American Gilsonite Co.

VALVES, TRAPS, AND PIPING

255 Choosing the Right Valve — Presenting valve selection as a matter of matching the valve's service characteristics with service requirements of the job, this practical 20-pp booklet explains and illustrates basic design features of gate, globe and check valves. It tells, in non-technical language, how each of these valve types works, and where it is suited for use. Disc, stem connection, bonnet and bonnet-joint characteristics covered. Crane Co.

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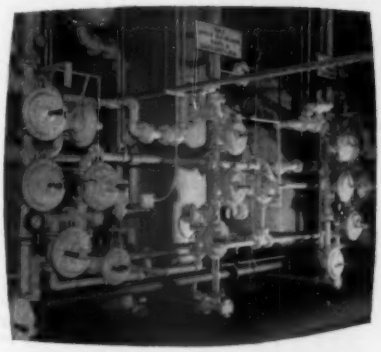

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256 Industrial Valves — Condensed Catalog 105, 28 pp, contains data on valves for a wide variety of applications. Includes dimensions and illustrations, describing non-return (stop-check) valves, globe and angle stop valves, pressure seal design, angle univalves and small size globe valves designed for chain or extension operation in vertical lines. Edward Valves, Inc.

257 Water Hammer Control— Cause, effect and control of water hammer in piping systems is the subject of 8-pp Bulletin WH 851. Photos, drawings and curves supplement text, and tests data is presented to show efficiency of company's silent check valves in water hammer control. The Williams Gauge Co., Inc.

258 Forged Steel Valves — Featured in comprehensive Catalog F-10 is detailed information and engineering data on company's line of forged steel valves, fittings, flanges and unions. Includes photos and cutaway views illustrating component features, as well as tables giving dimensional data. An engineering design section with complete specifications and pressure-temperature tables is included. Henry Vogt Machine Co.

259 To Get at Those Valves — This little folder describes a sprocket rim with chain guide. The rim adjusts to fit all valve wheels. Babbitt Steam Specialty Co.

260 For Lightest Condensate Loads — Bulletin T1744 (58) describes company's No. 30 impulse steam trap for use where condensate must be handled in very small amounts. Lists advantages and applications, tells how trap works and gives capacities, dimensions, materials used, prices. Yarnall-Waring Co.

261 Steam Traps — Bulletin 808 contains descriptive information on a line of combination float and thermostatic type steam traps. Cutaway views illustrate details of operation and design. Wright-Austin Co.

262 Ball Float Traps — Eight-pp Bulletin 2891 describes a line of ball float traps for draining water from air, gas or steam lines, and for draining light liquid from gas under pressure. A section on how to select ball float traps is included. Armstrong Machine Works.

263 Insulated Piping — Described in 20-pp Catalog 59-1 are prefabricated insulated piping systems for underground and overhead use. Cutaway views showing design and construction features are included, as well as dimensional diagrams and data, and photos of typical applications. Ric-wiL, Inc.

264 Welded Steel Pipe — Welded steel pipe for industrial uses is featured in 40-pp Catalog 8558. Describes applications, advantages, standard specifications, production limits, linings, coatings, fittings, joints, and gives other essential information. Also included are data tables, drawings, and illustrations of typical installations. Armco Drainage & Metal Products, Inc.

265 Flexible Ball Joint — Catalog 215-B, 20-pp, describes advantages of company's flexible ball joints for use in piping for power, process, heating, chemical, construction, or hydraulic service. Includes engineering specifications and data on the standard 300 lb series and the series 600. Screwed, flanged and welding end joints are listed, as are insulating joints and jacketed joints for handling asphalt and other liquids that solidify unless heated. Barco Mfg. Co.

266 Pipeline Strainer — Bulletin 1210B describes a line of self-cleaning semi-steel pipeline strainers in sizes from ¼ through 3 in. Construction features are detailed and dimensional data, weights and prices tabulated. Sarco Co., Inc.

267 UPVC Pipe, Fittings — Technical data and installation information on unplasticized polyvinyl chloride pipe are provided in 24-pp Booklet TTP-119. Also gives specifications for threaded and socket types of UPVC fittings, valves and flanges, of normal and high-impact material. Tube Turns Plastics, Inc.

268 Flexible Hose, Bellows — Sixteen-pp Catalog 187 describes applications and use of flexible metal hose and bellows. Engineering specifications and sizes, pressure ratings, materials and fitting attachments are included. Detailed drawings and pictures facilitate specification of individual applications. Flexonics Corp.

269 Expansion Joints — Advantages and features of company's line of expansion joints designed to prevent excess stresses due to expansion and contraction, to counteract vibration, and to insulate against noise are detailed in this 12-pp bulletin. Typical expansion joint installations are diagrammed and tables of dimensional data included. Goodall Rubber Co.

HEAT EXCHANGING

270 Heat Exchanger — Featured in this 12-pp bulletin is the Fin-Pak, a com-

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pact heat exchanger designed for a wide variety of fuel burning and process equipment. Structural details and operating principles are illustrated and typical installations shown. The Air Preheater Corp.

271 Plate Heat Exchanger — Eight-pp Bulletin A-1067 describes applications, dimensions, specifications and features of the plate heat exchangers, available in floor or wall mounted models. Installation photos are included in the bulletin. The De Laval Separator Co.

MECHANICAL POWER TRANSMISSION

272 Power Transmission Equipment — Bulletin 7900-BIP, 12 pp, is designed as a general catalog on mechanical power transmission equipment. Contains selection charts for heavy duty QD sheaves, light weight and QD Junior sheaves, V-belts, and variable speed drives, including all-speed drives, motor drives, and pulleys. Worthington Corp.

273 Worm Gear Reducers — Complete horsepower and torque data for company's worm gear units built on 2½ up to 4-in. centers are given in full-page tables in Bulletin 5018. Dimensions are diagrammed and tabulated in detail, and materials and design of interchangeable components are described. De Laval Steam Turbine Co.

ELECTRICAL EQUIPMENT

274 Electrical Enclosures — Bulletin EE, 14 pp, describes company's line of sheet metal electrical enclosures and other related items for a variety of applications. Covers control desks, electrical cabinets and enclosures, power distribution and control panels, boiler, turbine generator control panels, switchgear housings, and others. The Kirk & Blum Mfg. Co.

275 Testing Instruments — Bulletin 19–58, 16 pp, features company's electrical testing instruments, including ohmmeters, ground testers, dielectric test sets, motor rotation tester, cable fault locating equipment, transformer turn ratio test sets, corona test equipment, frequency meters, tachometers, others. Includes photos of each type. James G. Biddle Co.

276 Handbook on Fuses — This 12-pp booklet contains practical information on how to get safe, dependable, trouble-free electrical protection. Shows what to do when fuses blow, how to determine cause of blows, what kind of fuse to use for various circuits. Contains short history of fuses and notes on construction of fuses. Bussmann Mfg. Co.

277 Tube Raceways — Described in 28-pp Catalog 5912 are two systems of support for all types of cables, wiring and tubing. Design and construction features are detailed, and load charts and dimensional data and detailed diagrams are included. The Globe Co.

OTHER EQUIPMENT

278 For Quiet Heating — Described in this bulletin is the HusHeater, designed to heat — without making a sound — water and liquids by introduction of steam into the liquid. Lists advantages of the HusHeater. Most common application is in filter boxes and hotwells. Sims Pump Valve Co. Inc.

280 Automatic Data Systems — Described in Bulletin MSP-154 are electronic data handling systems for logging, monitoring, and integration of process information. Discusses basic design parameters, programming, switching, analog to digital conversion, linearization, calibration, digital ranging, print-out and off-normal alarms, remote switching, digital variable indication, integration, computation. Hagan Chemicals & Controls, Inc.

281 Fuel Oil Additive — Described in this product sheet is an additive for boilers suffering from "tired" fuel oil. Advantages and characteristics are detailed. Kor Corp.

282 Pneumatic Tools — Described in Catalog PT-58, about 12 pp are portable pneumatic production tools including grinders, attachments and accessories, wire brushes, hose and fittings, air line controls. Provides design features, application suggestions, sizes. Thomas C. Wilson, Inc.

283 Freon Solvents — Applications of Freon solvents for hand-cleaning operations as well as in degreasing equipment are detailed in this product bulletin. Properties of Freon solvents are tabulated and advantages pointed out. E. I. du Pont de Nemours & Co.

285 Story of Coal — This pocket-size booklet presents a complete picture of company's operations, traces the history of the coal industry and describes the many services and applications of coal. A colorful mural reproduced in the booklet pictures the part coal has played in civilization. Peabody Coal Co.

286 Steam Turbines — The advantages of company's solid wheel turbines,

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Adjustable SPROCKET RIM *with Chain Guide*

- Simplifies pipe layout
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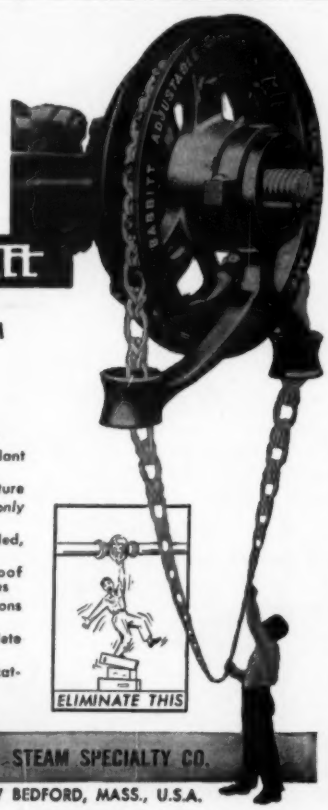

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axial flow turbines, single stage and multi-stage, are outlined in illustrated Bulletin S-140. Describes various models in their line. The Terry Steam Turbine Co.

287 Air Engineering — Eight-pp Bulletin 135 describes a line of air engineering equipment for process and chemical industries, including after coolers, air liquefaction system coolers, blowers, air conditioners, liquid coolers, coils, heat exchangers, heaters, dryers and vapor condensers. Photos and diagrams are included. Niagara Blower Co.

288 Equipment Selector Charts — Bulletin CE-50, 20 pp, contains selector charts on corrosion-resistant equipment for process industries. Tables cover general considerations in selection of material, physical properties, corrosion resistance. Describes rubber and plastic pipe, tubing and fitting; valves; pumps; lined tanks. Amerace Corp, American Hard Rubber Co.

289 Scale Remover — Advantages of company's "Dry Lightning" agent for scale removal from piping, coils, pumps, compressors, condensers and other equipment are detailed in this informative pamphlet. How to use the material is covered. Western Chemical Co.

292 Soot Blower — Bulletin 1030 describes a long retractable soot blower for cleaning of extra-wide furnaces. Cutaway diagrams showing details of design and construction are included. Copes-Vulcan Div., Blaw-Knox Co.

294 Plumbing, Heating Supplies — Edition H is the current edition of this company's 126-pp general catalog on plumbing and heating repair parts, tools and accessories. Indexed and illustrated, the catalog gives information on uses. J. A. Sexauer Mfg. Co., Inc.

295 Laboratory Supplies — This 12 pp price list announces latest prices for a wide range of laboratory supply items, including water analysis sets, conductivity equipment, colorimetric comparators, glassware and supplies, chemical reagents, and company's photometer with replacement accessories. Betz Laboratories, Inc.

296 On Model Studies — Advantages of model studies for precipitators and other gas handling systems are presented in this 18-pp brochure. Discusses three plans under which this new engineering service is available. Several case histories are detailed to show benefits obtained. Also provided are articles on the subject reprinted from POWER ENGINEERING and other publications. Research-Cottrell, Inc.

297 Instrument Tubing — Detailed information on various types of instrument tubing and accessories is presented in this 16-pp bulletin. Among tubing described is extruded polyethylene tubing, extruded nylon tubing, tubes of copper, aluminum, and/or steel with polyethylene sheath, tubing with vinyl sheath, bundled instrument tubing. Dekoron Products Div., Samuel Moore & Co.

298 Cranes, Hydro Equipment — Twelve-pp Brochure HY-51 describes cranes and equipment for hydroelectric, water supply and other applications. Various components and assemblies that help harness hydroelectric power are pictured, including cranes and hoists, gates and valves, and special hydroelectric equipment. Yuba Consolidated Industries, Inc.

299 Is Salt Just Salt? — This is the title of an 8-pp bulletin describing salt characteristics and properties as well as geographical distribution. Variations in salt from different areas in the United States are illustrated and company's refined products described. Morton Salt Co.

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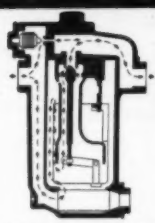

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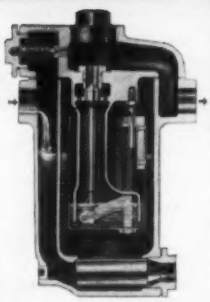

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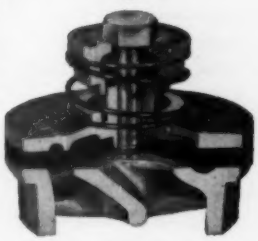

Write for Bulletin V-112 explaining how Sims Valves can improve your pump operation at lower cost.

Sims **PUMP VALVE CO., INC.**
1314 PARK AVENUE, HOBOKEN, N. J.

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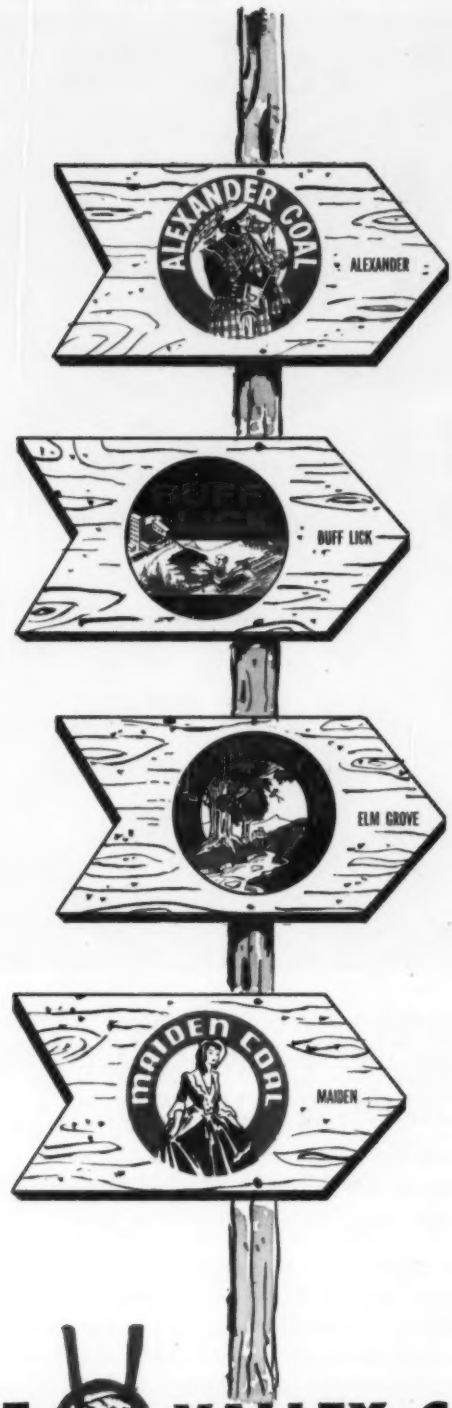

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One of these Valley Camp Quality Coals can be a direct way toward lowering your steam costs. They are prepared to specification in modern plants, available for shipment via rail or river . . . and, our combustion engineering service will be glad to "show you how".

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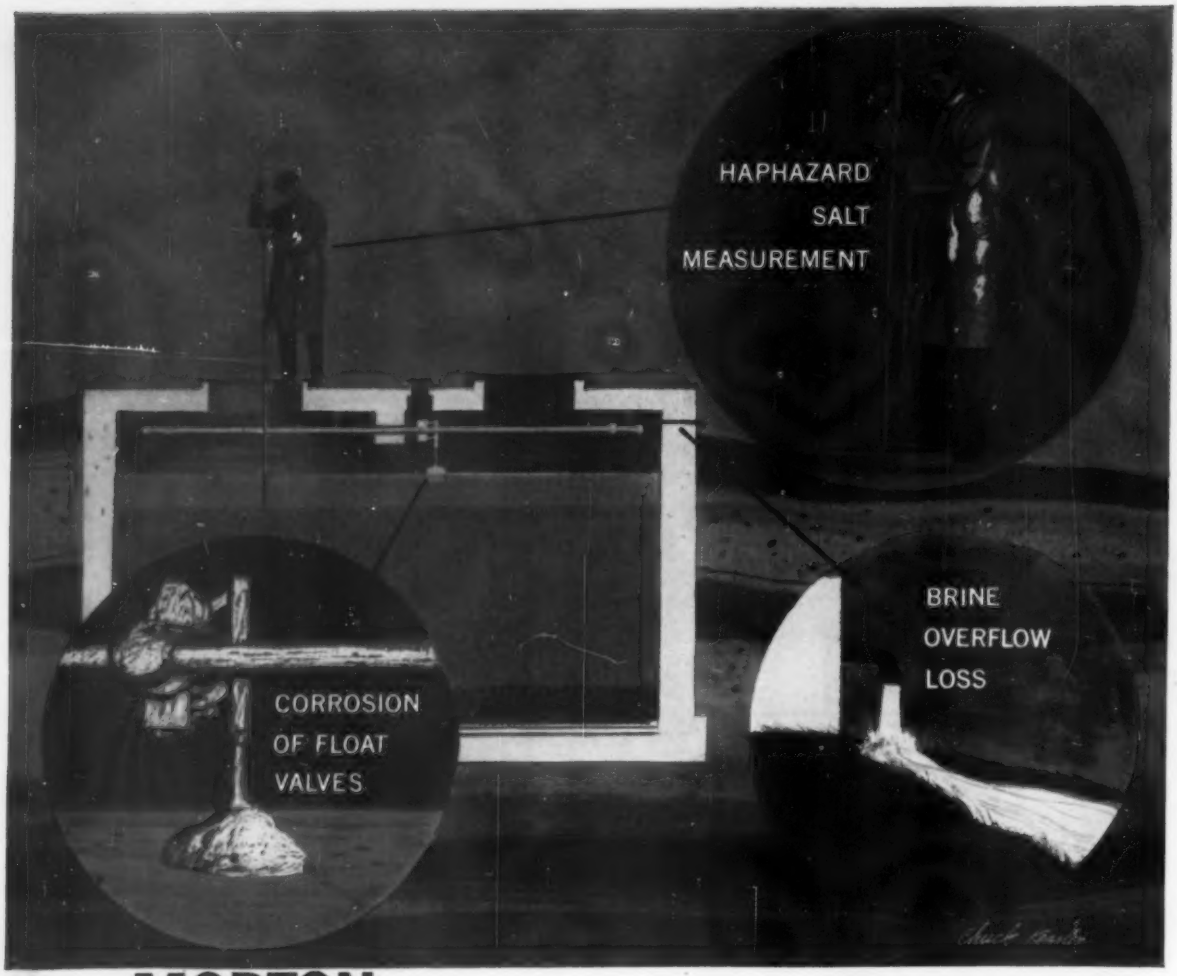

New MORTON LEVETROL* system solves these common wet salt storage problems for you

*Levetrol is a method of liquid level control in a wet salt storage system where water level automatically is proportioned to brine withdrawn.

The Morton **Levetrol** System is adaptable to any wet salt storage system. It protects you against salt loss due to brine overflow by balancing your water level with your salt level. **Levetrol** solves the problem of salt and water inventory . . . protects against completely drained salt storage supply . . . enables you to have complete automation of your entire water treatment system.

Levetrol eliminates the problem of corroding float valves. All **Levetrol** controls are located away from your brine storage supply to completely avoid corrosion and assure convenient, accurate salt measurement and proper brine strength at all times.

For complete details on the Morton **Levetrol** System for your wet storage system, write us today!

Please send me, without cost or obligation, more information about the new Morton **Levetrol** System.

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Street_____

City_____ Zone_____ State_____

Approx. size of wet storage system_____

MORTON SALT COMPANY

INDUSTRIAL DIVISION

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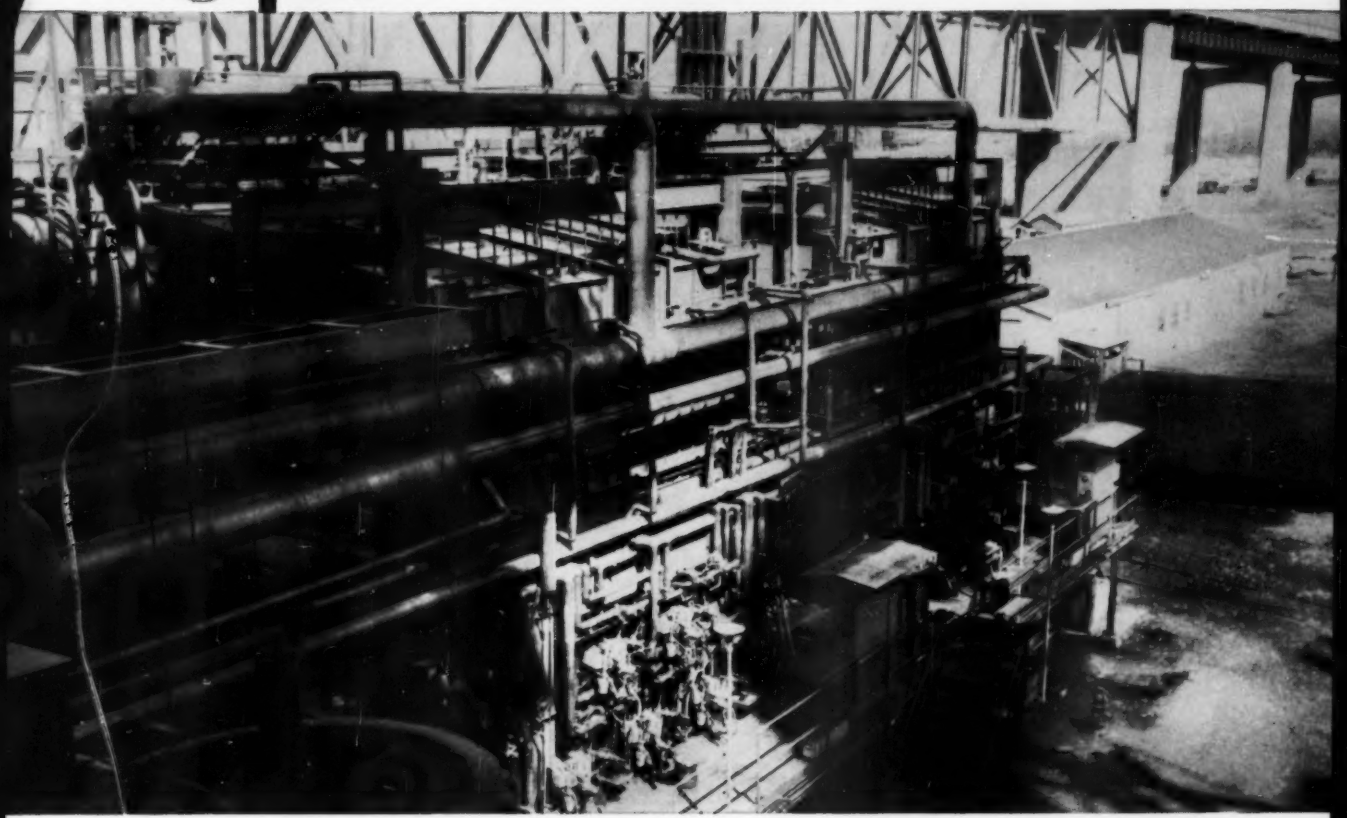
How Copes-Vulcan control systems boost power plant efficiency



Outside boilers and boiler controls subject to severe weather, with temperatures as low as 10°F. Except for the central control panel, the Copes-Vulcan control system is entirely outdoors. Each boiler has a maximum continuous rating of 150,000 pounds per hour at 230 psig saturated.

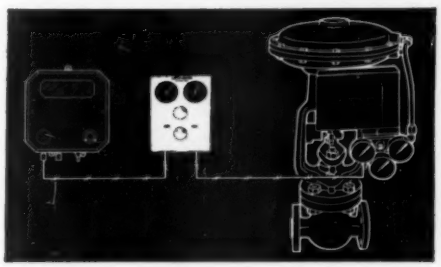
Copes-Vulcan boiler control meets unusual load conditions at Deepwater Station

Besides producing power for the Atlantic City Electric Company system, the Deepwater plant delivers steam to an adjacent chemical plant for process use.

To meet the fluctuating process demands, Copes-Vulcan controls the two low pressure boilers with precision responsiveness.

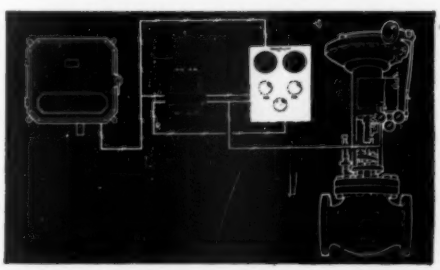
The system consists of: Combustion control . . . Copes Type 3-L Feedwater Control . . . Boiler feed pump recirculation control . . . and Vulcan rotary soot blowers. The system controls all equipment, permits each boiler to carry a different load. Control is automatic through the load range from 20,000 to a peak-load of 200,000 pounds per hour.

Whether your boiler is large or small, power or process, Copes-Vulcan can provide a unit or an integrated package, custom designed to your requirements. For details on the Deepwater Station, write for Bulletin 1057.



PNEUMATIC CONTROL STATIONS. Copes-Vulcan stations offer automatic-to-manual selection without the complication of seal balance. They indicate process-variable, controller, and manual loadings. Transfer is "bumpless" without process disturbance. Write for Bulletin 1031.

The AM-4 Selector Station (shown above) indicates an automatic loading—or originates a manual loading to the valve, power cylinder, or other control elements.



The AMS-4 Remote Set Station (shown above) permits manually adjustable set-point loading, or independent manual operation, of the control element.

Copes-Vulcan Division
BLAW-KNOX COMPANY
Erie 4, Pennsylvania

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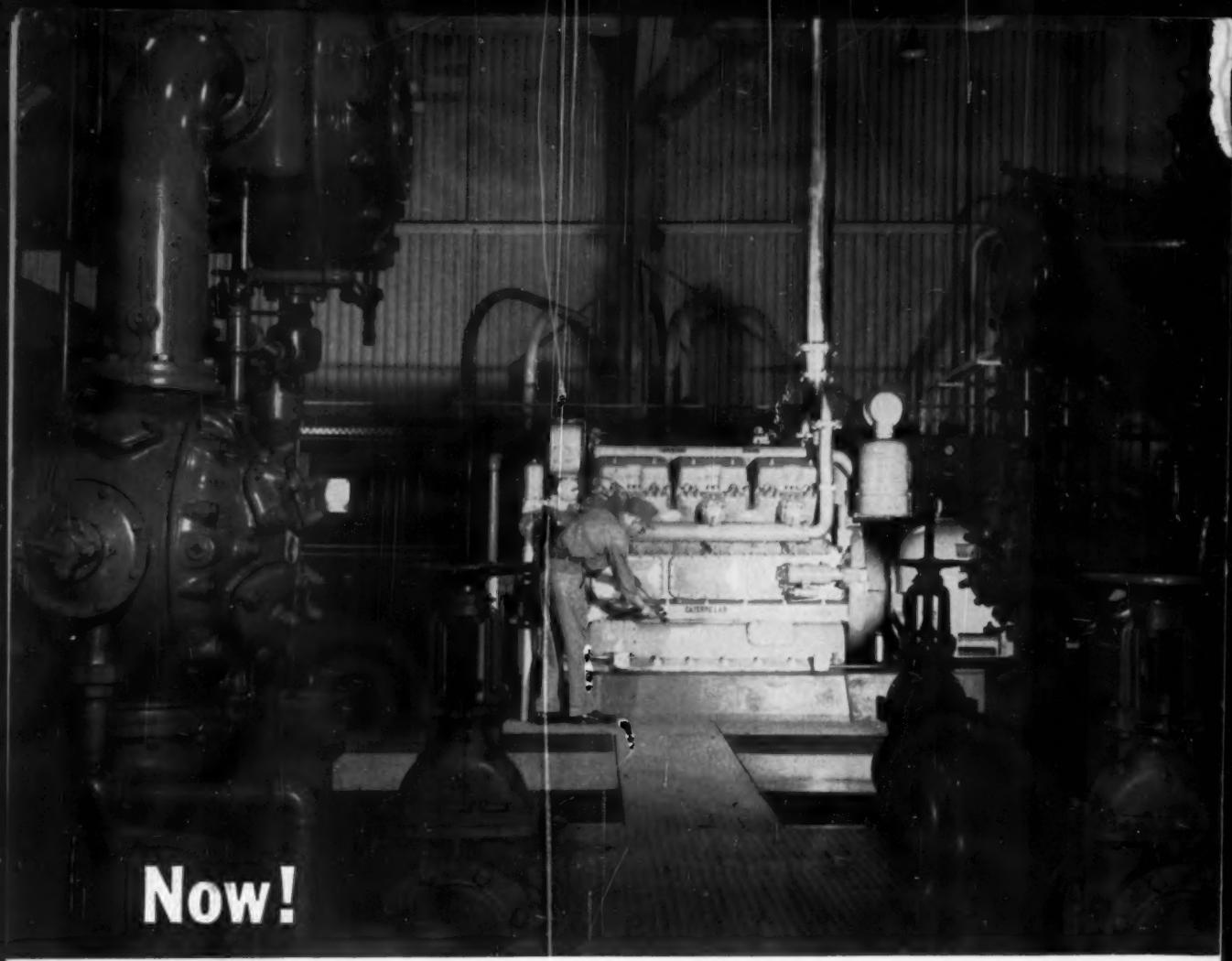

Effective auxiliary equipment maintenance requires no more than 4 lubricants

Get important reductions in inventory and maintenance costs with Texaco Organized Lubrication

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As a result of this plan, inventory is cut sharply; storage space is saved. Misapplication dangers are substantially reduced. Lubrication rounds take less time—labor costs go down.

A Texaco Lubrication Engineer will be glad to tell you how the Organized Lubrication Plan can help you cut maintenance costs in your plant. Just call the nearest of the more than 2,000 Texaco Distributing Plants, or write:

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LUBRICATION IS A MAJOR FACTOR IN COST CONTROL

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